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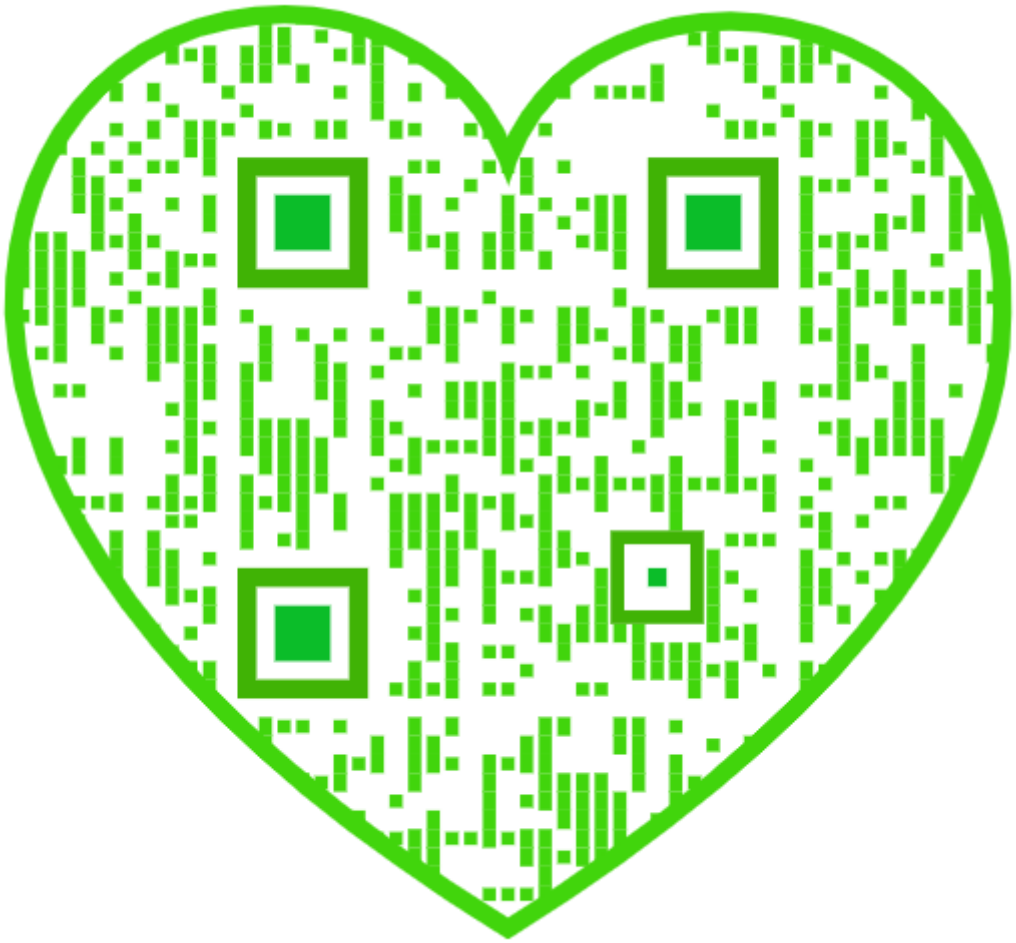

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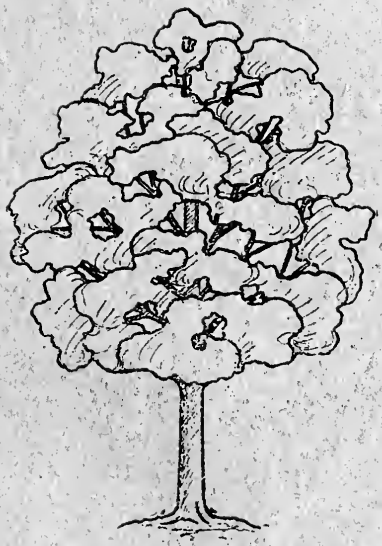
The Planting and Care of SHADE TREES



NEW JERSEY
FOREST COMMISSION

DEC

FOREST PARK RESERVATION COMMISSION
OF NEW JERSEY

600
24

THE PLANTING AND CARE OF SHADE TREES

By ALFRED GASKILL, State Forester,

INCLUDING PAPERS ON

Insects Injurious to Shade Trees

By JOHN B. SMITH, State Entomologist,

AND

Diseases of Shade and Forest Trees

By MEL. T. COOK, State Plant Pathologist.

TRENTON, N. J.
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The Forest Park Reservation Commission.

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Introductory.

The first two of this series of papers, with one on Fungi of Native and Shade Trees, by Dr. Byron D. Halsted, were originally published in the report of the Forest Park Reservation Commission of New Jersey for 1908. Appreciative demands having exhausted the edition, Mr. Charles Lathrop Pack, a member of the Forest Commission, and a well known pioneer in Forest Conservation, generously offered to defray the cost of a new issue. This offer was accepted and the Forest Commission has caused two of the papers to be thoroughly revised and a new one dealing with tree diseases to be prepared by the recently appointed State Plant Pathologist.

Authority.

The State is committed to the policy of protecting, improving and increasing the number of its shade trees. This bulletin is published under the direction of the Forest Park Reservation Commission with the co-operation of the Trustees of the State Agricultural Experiment Station. Each paper is by an acknowledged authority in his line.

Fig. 1. Elms 30 years old, well placed, well spaced, well guarded. (Courtesy of U. S. Forest Service.)

Scope. The reader is reminded that none of the papers pretends to be exhaustive of its subject; each deals in the briefest possible way with the things that concern the trees of the State, and aims to tell what to avoid as well as what must be done. The bulletin will serve as a manual to those who are accustomed to working with trees, and will guide those who seek to travel an unknown, though it may be an attractive, path. More detailed information will be found in the books listed on page 123, though for any important work tree owners are advised to seek the assistance of a reputable tree planter, tree doctor, arborist or forester. The Agricultural Experiment Station and the Forest Commission have lists of such and will furnish them upon request.

Assistance offered. Both offices are prepared to give advice by mail on any matter relating to trees, and, when necessary, either will have a competent man make an examination and report. Any municipal body, as a shade tree commission, or the managers of a public institution, will be aided without charge; individuals will ordinarily be required to pay the consultant's expenses, but not his salary.

The Planting and Care of Shade Trees.

By Alfred Gaskill and James O. Hazard, *Foresters.*

New Jersey is fortunate in having a soil and climate so favorable that many species of trees can be grown in any part of it, or some species found for almost any situation. It must be urged, however, that only a few trees withstand the trying conditions imposed by city streets and buildings, or the rigors of the sea coast. Attention is, therefore, given chiefly to street trees, for the number which may be grown successfully on any well kept lawn, even in a city, is very great. Upwards of forty species are found in more or less thrifty condition on the street, parking and lawns within two blocks of the State House, and many more might be planted that would do as well.

Conditions favorable and unfavorable.

Street Trees.

There is little use trying experiments with trees for street planting. At the best, a tree on a city street is out of its element and at a disadvantage; chose, therefore, amongst the few that are known to thrive under your conditions, get good trees, plant them carefully, and take care of them.

REQUIREMENTS.

A street tree should be chosen for its (1) *Form*, (2) *Hardiness* or *Adaptability*, (3) *Rapidity of Growth*, (4) *Shade Production*, (5) *Neatness*, (6) *Beauty;* the various qualities ranking in about the order given.

1. *Form* is placed first because, no matter how good the

tree, it is a failure if it does not fit the situation. By careful pruning almost any tree can be made to grow upright, or to develop a broad crown, but it is much better to chose a species that naturally takes the desired form. Trees are beautiful, or otherwise, as they harmonize with their surroundings.

On narrow streets with houses close to the curb only slender trees of moderate height growth should be planted. Red maple, red gum, ginkgo, are good. For wider streets, or those with parking in front of the houses, larger trees like Norway maple, basswood, horse chestnut, or pin oak, may be chosen. Wide avenues should be dignified with the most majestic trees—white elm, white oak, red oak, tulip poplar.

2. *Hardiness and Adaptability* are qualities of prime importance in a street tree. Under any circumstances careful consideration must be given to the native soil, the pavement, the nearness of buildings, as well as to the vigor of the tree itself and its power to adapt itself to unusual strains. Strength to withstand the pressure of wind, snow, ice, etc., ability to recover from mechanical injuries, and resistance to insect attack and to disease are also factors. No tree at all susceptible to frost should be planted in this State. Sweet gum grows well in clay but not in sand; sugar maple and basswood suffer from leaf burn when over a smooth, light colored pavement; horse chestnut is apt to be infested with insects and fungi.

A street tree must be resistant.

3. *Rapidity of Growth.* To most people who plant trees that which grows most rapidly is best. Thus our streets are filled with silver maples, box elders and cottonwoods instead of Norway maples, oaks and elms. Quick growing trees are desirable, yet it is a fact that those which grow most rapidly are commonly the shortest lived. Plant silver maple or cottonwood if you must have a good sized tree in a hurry, but don't forget that it will have to be replaced when a Norway maple, a red oak, or a sycamore is at its best. And bear in mind that cultivation and care will make any good tree grow comparatively rapidly. A red oak well nurtured will increase in size faster than a maple that is neglected and abused.

Quick growing trees are short-lived.

Fig. 2. A good row of trees but houses too much shaded. See Figs. 4 and 14.

4. *Shade Production.* On many streets it is easily possible to have too much shade. (Fig. 2.) Houses and sidewalks need sun even in summer; therefore, on narrow streets trees with light foliage, like the locusts and ashes, will usually be better than the denser crowned maples, etc. Early leafing is never desirable.

5. *Neatness.* A tree is a nuisance when it litters the street with its bloom or fruit, sends up many suckers, heaves the pavement by its superficial roots, emits an offensive odor, or attracts insects. Cottonwoods or poplars are, therefore, to be avoided because, among other reasons, they cover the ground with their bloom in the spring; silver maples will break up any pavement; ailanthus has a very bad smell for several weeks each year unless the trees bear pistillate flowers only; mulberry has a fruit which when crushed makes the sidewalks slippery and dangerous.

Avoid trees that are offensive.

PLATE I.

SHADE TREES GOOD AND BAD IN ONE NEW JERSEY CITY.

A. Extreme Neglect: the Pole Looks Better Than the Tree.

B. No Tree can Thrive Where the Pavement is so Close.

C. A Street Tree that is Bad in Every Way: It Forks too low and has no growing space.

D. A Worse than Useless Guard. It is too low to prevent horse-biting, and so small that the tree is choked.

E. A Newly-planted Tree Protected by a Guard that is Entirely too Light, and with no Growing Space.

F. A Guard Outgrown and Sidewalk Displaced by Root Growth.

G. A Good Temporary Guard, but too Light to last Long. Growing space much too small.

H. A Good Guard but Evidently not Placed Until After the Tree had been Badly Injured by Horses. Growing space entirely too small.

I. A Tree Well Guarded and Well Provided with Growing Space.

J. A Thriving Street Tree. It has a fair growing space and is sufficiently guarded with wire.

K. A Growing Space like that Provided for this Tree Interferes Little with the Footway.

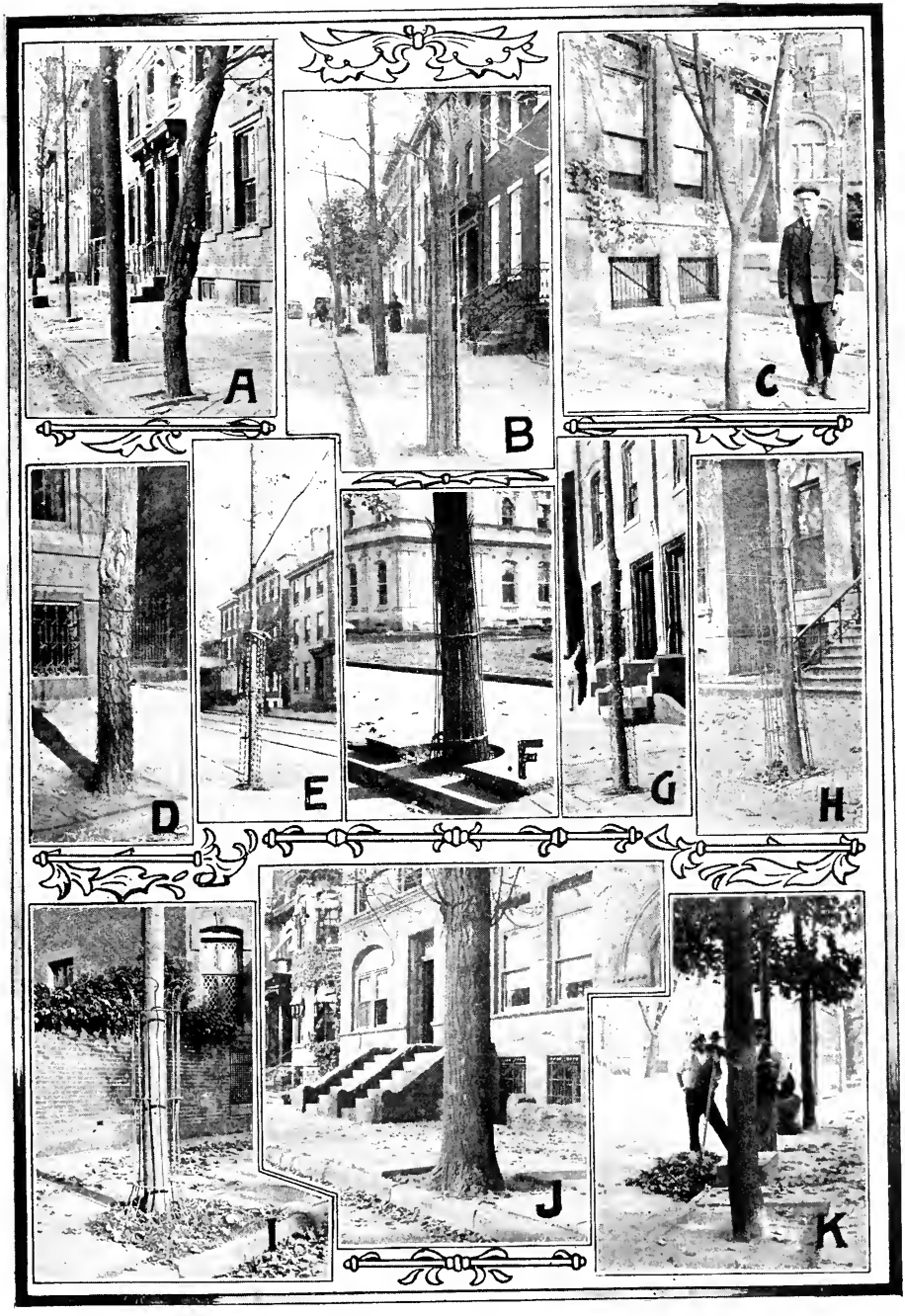

Plate I. See descriptions opposite.

6. *Beauty.* The idea of beauty in a tree is satisfied when it is normal in form, vigorous in growth, healthy, and suitably placed. Street trees always suffer by contrast with those in natural situations, yet when arranged harmoniously in well-spaced rows, the uniformity of the trees matching the uniformity of the street, most satisfactory results are obtained. This rule demands that all the trees on a street, or at any rate all in a block, shall be of the same kind and as near alike as possible in size and shape. See Figs. 1 and 4.

Uniformity.

In choosing shade trees, it is always proper to consider the buds, twigs, flowers, fruit and coloring of the leaves. The pendant, spiky balls of the red gum are as attractive through the winter as its brilliantly colored leaves in the fall. Of all the trees fit for street planting the most gorgeous are the maples in their autumn dress. The spring beauty of the horse chestnut in bloom is largely offset by its dilapidated appearance in early autumn, when most other trees are still fresh.

Fruits, flowers, color.

Fig 3. A residence street insufficiently shaded. See Figs. 4 and 26.

WHAT TO PLANT.

The list of trees capable of meeting the conditions in a city street is not long; it might indeed be curtailed to less than a dozen. Evergreens are excluded altogether because their shade is not wanted in winter. The following list is arranged to show the trees best adapted to streets of various widths and includes all the species, foreign as well as native, which are in any way suitable, except perhaps on wide streets where lawn conditions are approached. Those at the top of each column are preferred to those farther down. See pages 56 to 65 for descriptions of each species.

Evergreens excluded.

THE BEST TREES FOR CITY STREETS.

Narrow Streets. (less than 60 feet wide between building lines.)	*Average Streets.* (60 to 90 feet wide between building lines.)	*Wide Streets.* (over 90 feet wide between building lines.)
Ginkgo	Norway Maple	White Elm
Red Gum	Red Gum	Red Oak
Red Maple	Pin Oak	Scarlet Oak
Norway Maple	Red Oak	Sycamore
Honey Locust	Scarlet Oak	Sugar Maple
Hackberry	Red Maple	White Oak
Green Ash	Sycamore	Tulip Poplar
	Basswood	Basswood
	Hackberry	Red Gum
	White Ash	Ailanthus
	Ginkgo	
	Honey Locust	
	Horse Chestnut	
	Sugar Maple	

Trees not recommended. From the foregoing list several trees universally found on city streets will be missed. *Silver,* or *white, maple* is a rapid grower and able to survive many handships, yet its youthful beauty is soon lost by the breaking of its fragile branches and a general early decay. It is also prone to disturb the pavement by the growth of superficial roots. The *poplars* or *cottonwoods,* of which there are several species, are even more rapid growers than the silver maple

when planted in rich, moist soil, and their slender habit adapts them well to narrow streets, but they are even shorter lived than the maple, are offensive by the litter that they make in spring and by the many root suckers that they produce. For these reasons they are excluded from the streets of Albany, N. Y., by a city ordinance. In Washington, D. C., the silver maples and poplars planted years ago are being replaced by other species. *Willows* have no recommendations whatever as street trees. None of these trees, therefore, should be planted unless it be for a momentary effect. Twenty years after planting, any of the trees recommended will be in better form and, if well chosen and properly cared for, almost as large. *Black locust* should not be planted solely because it is sure to be injured or destroyed by the borer worm. Except for this fault it makes a fine tree for narrow streets on account of its hardiness, narrow crown and fine foliage. *Beech* is a slow grower and casts too dense a shade for any street. It is further objectionable for any public place because its smooth bark tempts every jackknife carver. *Walnut* and the *hickories* invite injury by their fruit and, therefore, have no place as street trees. *Chestnut* is sure to fall a prey to the bark disease, see page 101.

Trees to avoid.

PLANT THE TREE THAT SUITS LOCAL CONDITIONS.

Any of the trees here recommended will grow in every part of the State but, after meeting other conditions, a careful planter will chose that whose natural habitat is nearest like the planting site. If the soil be very dry chose scarlet oak, hackberry, honey locust rather than white ash, white elm or Norway maple. If it be clay, red gum, pin oak or sycamore will be apt to do best. By changing the soil natural conditions can often be modified so that the preferred species may be planted. Any soil but the very best should be enriched when a tree is planted, for the needs of the tree are apt to be forgotten afterwards.

A close relation between soil and tree.

THE TIME TO PLANT.

Deciduous trees should never be transplanted while the leaves are on. Midwinter is not a good time because the ground is apt to be frozen. Late fall is often preferred, yet it is never well to expose a tree to the dangers of a winter before it has had a chance to grow new roots and fix itself in the soil. In this State early spring, just after the ground thaws, is by far the best season. Trees are then quick with new life and if moved can very promptly provide feeding organs and adapt themselves to changed conditions. If a drouth follows the planting, and spring drouths are common, the trees must be freely watered until they are established.

Spring best time to plant.

ARRANGEMENT ON THE STREET.

Uniformity. When planting is done by the property owners individual choice will naturally have the widest range—as to species, size, location and everything else. But every effort should be made to have all the trees on a street

Fig. 4. A residence street newly planted with Norway Maples, well grown and well placed. (Courtesy of the Newark Shade Tree Commission.)

the same kind, the same size, and uniformly spaced. (See Figs. 1 and 4.) Where the building lots are of various

widths uniform spacing is sometimes difficult, but there is no need to place trees in the same position in front of every house.

Spacing. Do not plant trees so close together that when grown they will interfere or entirely shade the house fronts. Too much shade is as bad as too little, and each tree should have room to develop its own form. (Fig. 4.) In blocks made up of lots 20 feet wide, or less, a tree should be planted in front of every other house only, those on opposite sides being alternated thus:

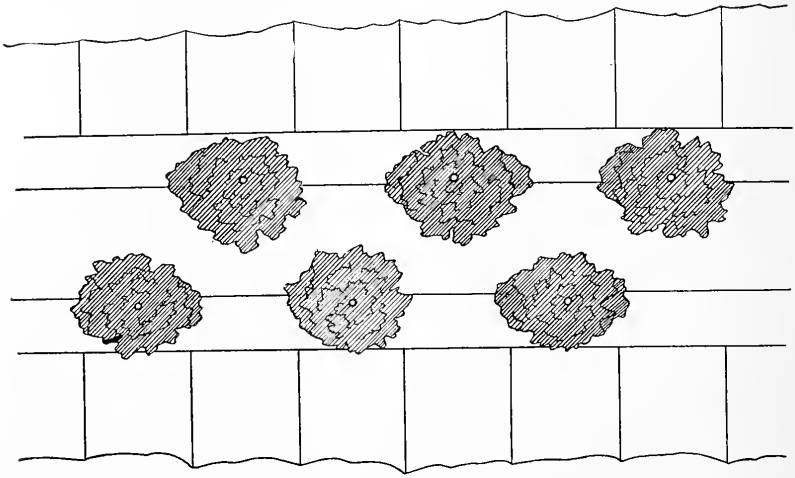

Fig. 5. How trees should be placed on a narrow street.

On wider streets, 40 feet, 50 feet, 60 feet or even more may be given to a tree according to its size and habit of growth, and the arrangement may be opposite or alternate according to conditions. But in every case the aim should be to develop rows, or blocks, of trees, rather than individuals. A quick effect can be secured by planting trees closely, and as they grow removing the alternate ones. But a very practical difficulty, apart from the cost, is that no one wants to thin them out at the proper time. If close planting is resorted to the intervals *must be* half or one-third the intended ultimate spacing.

Location. Where pavements are narrow the trees must be placed close to the curb in order that their crowns may have room in front of the buildings. They will be crowded at best. Where space permits it is best to plant inside the footway. There the trees are less subject to injury and shade the sidewalk and the houses rather than the road. See Fig. 14.

Don't plant close to curb.

Footing or Growing Space. As explained on page 24, every tree planted should have at least 6 square feet of open earth above its roots. If the sidewalks and roadway are paved with concrete this is even more important than where bricks, or other jointed materials are used. On narrow sidewalks the space may have to be limited to 1½ feet by 4 feet, but with that as a minimum strive for openings 3x8 feet, or better still, a continuous parking. Figs. 8, 14, 26, Plates I, II.

Give a tree room.

THE TREE.

Be sure to get healthy, well shaped trees. It is a waste of money and time to set the poor deformed things that nurserymen sometimes supply. Wild trees can be used, but they are less apt to withstand the shock of moving than those that have been transplanted once or twice. Don't seek cheap trees; get them from a responsible nurseryman.

Size. It is often possible to set out trees as much as 12 inches in diameter, but the cost increases much more rapidly than the size. As a rule the stems of the trees should be between 2 inches and 3 inches in diameter, and about 12 feet tall. This serves pretty well the common desire for early results at a reasonable cost.

Roots. Move a tree with as many roots as possible. It may grow if only the stubs of the main roots are saved; it will do much better if the whole root work within a radius of 2 feet is taken; give especial care to the finer rootlets, they are the ones that do the feeding. Never let them get dry; a dry root is dead!

Spare the roots.

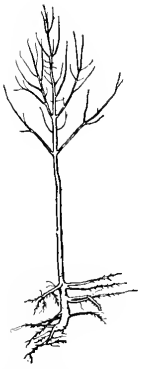

Fig. 6. Young tree as received from the nursery.

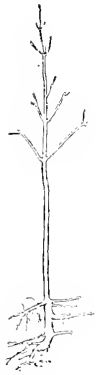

Fig. 7. Same with top and roots pruned.

Crown. Preserve the normal crown, or the form developed in the nursery, if possible. If the root system has been much curtailed it will be necessary to cut back the crown to maintain a balance between roots and foliage, yet this balance is much better kept by saving roots than by sacrificing branches. (Figs. 6, 7, 8.) Good trees rarely come from the bean poles that are often planted. The lower branches of a street tree should be not less than 10 feet above the sidewalk. While it is small something less may be permitted, but sufficient headroom should always be allowed passers-by. If this is not done the tree is sure to be injured. Observe how the branches bend when the leaves are wet with rain and give plenty of room for umbrellas. See *Pruning*, page 37.

Expand the crown.

THE HOLE.

Before a tree to be planted is brought on the ground have the hole made ready for it. If the site is on "made" ground take out at least a cubic yard of the rubbish and provide as much good loam. Then prepare the planting hole, by digging or by filling as the case may be, so that it shall be somewhat larger than the root area, and about a foot deeper than the roots. On the bottom spread a layer of fine, mellow soil

mixed with one-third its bulk of well rotted (not fresh) stable manure. Have the space above this bed just deep enough to accommodate the roots and allow the tree to stand about 2 inches deeper than it did in the nursery—not more.

Prepare the place for a tree.

PLANTING.

If a choice is allowed always transplant a tree on a cloudy day; a bright sun quickly exhausts the stored up moisture. But whenever the tree arrives get it into the ground without delay. Thoroughly wet the earth in the hole that has been prepared, set in the tree and spread out the roots so that they lie naturally and are not crossed. Cut off with a sharp knife all that are broken or badly bruised. A mutilated root invites decay. Then fill in finely pulverized earth, work it under and around the roots by hand, and compact it firmly. Do not let any manure come in contact with the roots. If the earth is wetted down as it is put in it will make a much better contact. Fill the hole to the ground level when well compacted, then rake over the surface and pulverize it to a depth of about an inch. Two points are very important: keep the tree vertical and be sure that all the roots are well embedded. It is possible to injure the roots by making the earth about them too hard, yet more trees are lost through faulty root bedding than in any other way. Remember that a tree feeds by its roots; to do that every smallest rootlet must be firmly *in* the soil.

Imbed each rootlet.

When planted tie the tree to a strongly set stake, or place the guard about it at once.

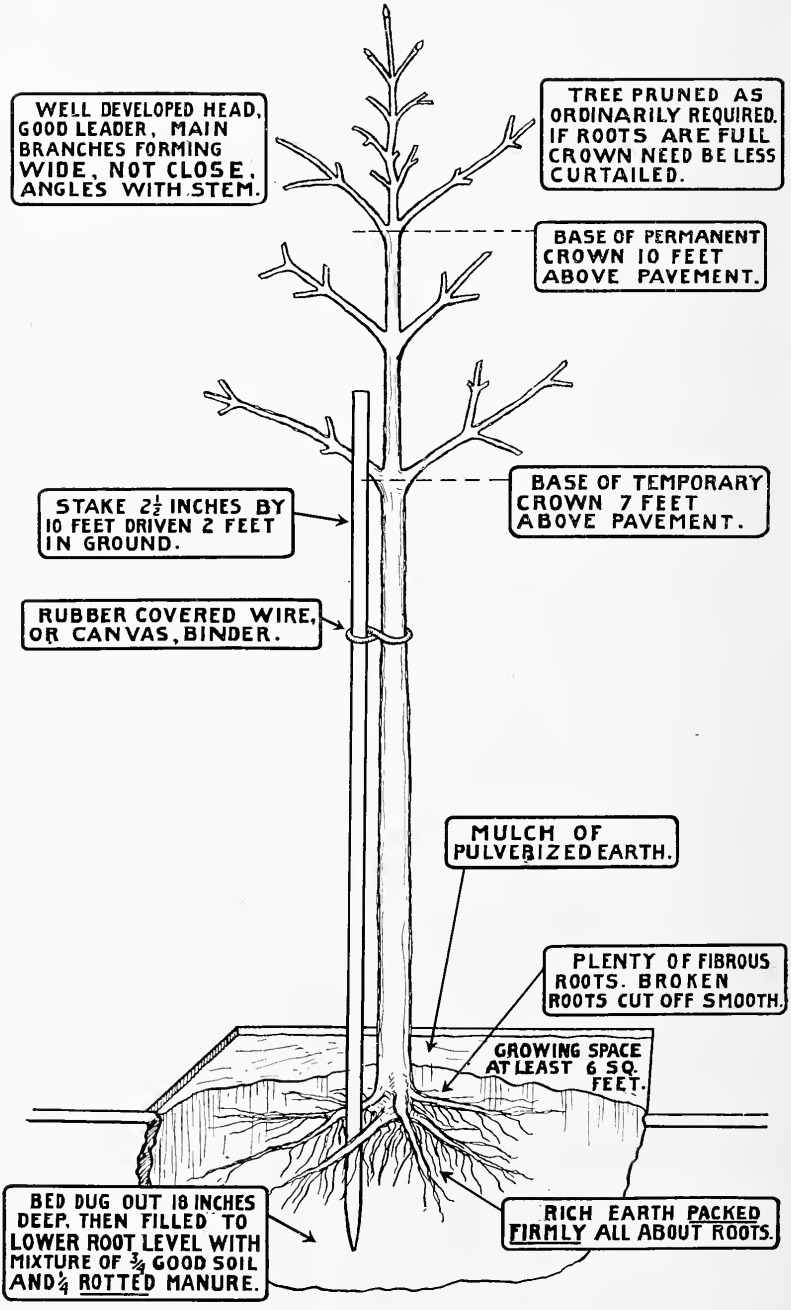
WELL DEVELOPED HEAD, GOOD LEADER, MAIN BRANCHES FORMING WIDE, NOT CLOSE, ANGLES WITH STEM.
TREE PRUNED AS ORDINARILY REQUIRED. IF ROOTS ARE FULL CROWN NEED BE LESS CURTAILED.
BASE OF PERMANENT CROWN 10 FEET ABOVE PAVEMENT.
BASE OF TEMPORARY CROWN 7 FEET ABOVE PAVEMENT.
STAKE 2½ INCHES BY 10 FEET DRIVEN 2 FEET IN GROUND.
RUBBER COVERED WIRE, OR CANVAS, BINDER.
MULCH OF PULVERIZED EARTH.
PLENTY OF FIBROUS ROOTS. BROKEN ROOTS CUT OFF SMOOTH.
GROWING SPACE AT LEAST 6 SQ. FEET.
BED DUG OUT 18 INCHES DEEP, THEN FILLED TO LOWER ROOT LEVEL WITH MIXTURE OF ¾ GOOD SOIL AND ¼ ROTTED MANURE.
RICH EARTH PACKED FIRMLY ALL ABOUT ROOTS.

Fig. 8. Diagram—How to plant a street tree.

IT IS IMPORTANT TO OBSERVE EVERY POINT INDICATED IN THE DIAGRAM.

CARE OF TREES.

No tree on a city street can look out for itself; it must be taken care of. This involves protection against injury of every kind, provision for necessary nourishment, and, at times, some help to ward off insects or disease.

GUARDS.

The first needs of a newly planted street tree are a stake to keep it upright, and a guard to protect it against horse-biting, wheel scraping and all mechanical injury. Young trees are best protected by devices which serve as well for support, as the ugly, but practical, box used in Washington, D. C. (Plate II. C.) Those that are established need only a shield against horses and accidents, or none at all if the police regulations are enforced. Various forms of guards are shown in Plate II. Any of these is good but unless it is strongly fixed in the ground the young tree should be fastened to a stout stake as in Fig. 8. In binding a tree to a stake, or to a guard, the bark must be shielded against rubbing. For this purpose wire covered with rubber hose is much better than cords. Don't let a tree break loose from its guards. It will get beyond the need of support in a year or two, but will always be subject to abrasion. As the tree grows see that its guard and fastenings do not cramp it. Keep the guard painted and in good repair. The necessity for constantly looking after tree guards shows how much the trees would suffer without them. (See Plate I.)

Police regulation better than mechanical guards.

PLATE II.

TYPES OF TREE GUARDS AND GRATINGS.

All but cut G from photographs by Dr. W. A. Murrill, of the New York Botanic Gardens.

A. Tree Guard and Bench. London.

B. Young Sycamore with Pole Support. Wire Guard and Grating. Paris. The enlarged bases of the guards in cuts B. H. I., and the sheet iron on the guard in cut F, are to protect the trees from dogs.

C. The Standard Guard used in Washington, D. C. This is strongly made of wood, is firmly fastened to four diagonal stakes driven into the ground, and, by leather bands at the top, supports the tree as well as protects it. These guards are unsightly and harbor insects, but they are always removed after the tree is well established.

D. A Simple Guard of Wire Netting. Washington, D. C. This, and all kinds of metal guards, are now being discarded and the older trees left to the protection afforded by stringent police regulations and systematic inspection.

E. A Guard of Pine Poles. Berlin. Not so cheap here as in Germany and otherwise not desirable.

F. Wire Guard with Sheet-Iron Base to protect the tree from dogs. Frankfort, a. m.

G. A Neat Iron Guard but too Light to last Long. Trenton, N. J. Contrast small growing space with spaces shown in other pictures.

H. Young Tree with Wooden Support, Iron Guard and Grating. Berlin.

I. Older Tree with Guard and Grating. Paris. Contrast large grating in concrete pavement with smaller grating in broken stone pavement, cut H.

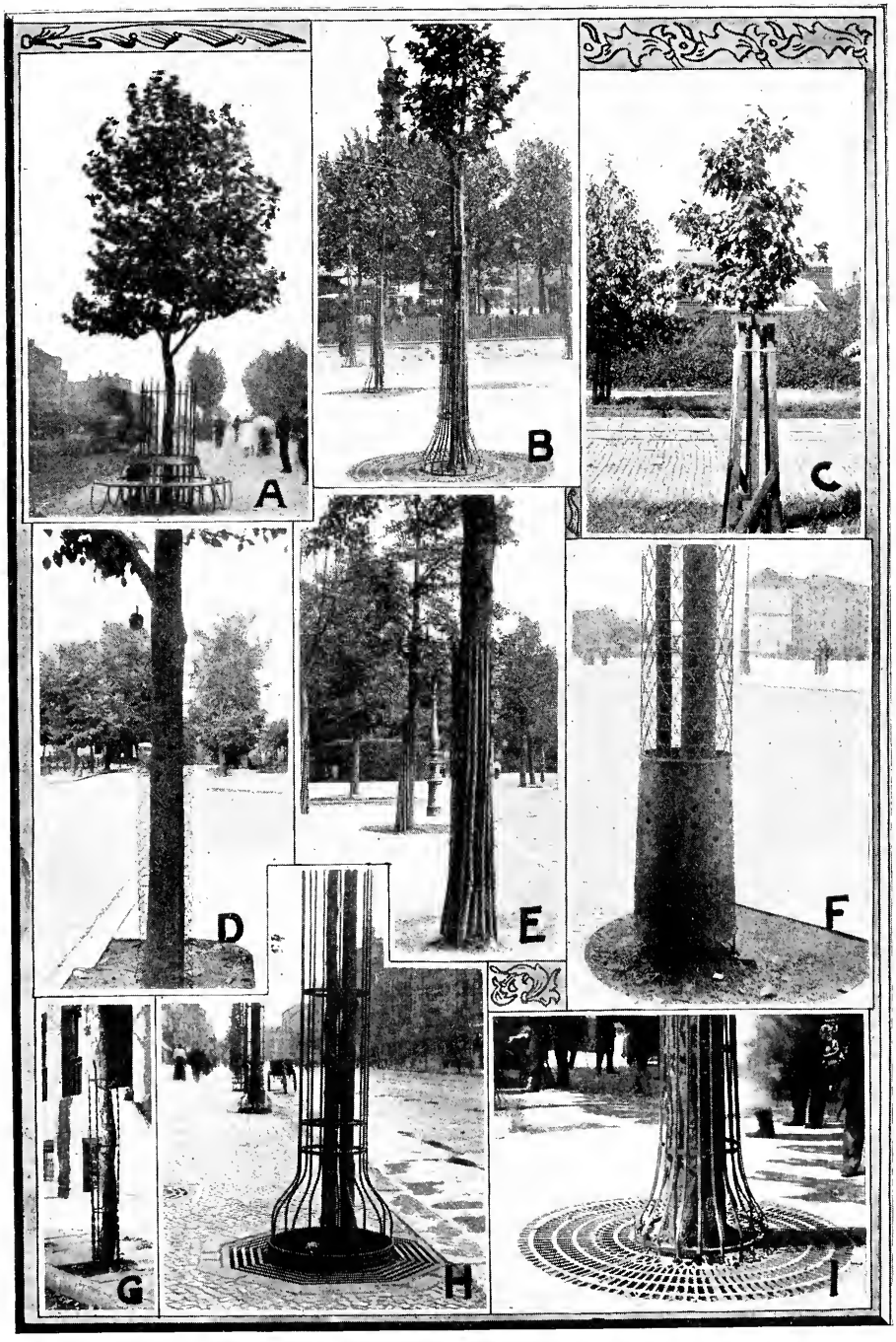

Plate II. See descriptions opposite.

Gratings. In some cities the bases of trees are protected and their roots given air, by means of iron gratings set in openings in the pavement. Plate II. shows a number of these. In exposed situations these gratings are valuable, but apart from their considerable cost they must be raised frequently and the space cleaned out. It is well to avoid their use as far as possible.

NOURISHMENT.

More street trees suffer from starvation than from anything else. In many places food, water and air are all denied; and the greater part of the harm is done by laying the pavement close to the tree. Don't plant a street tree unless it can have six square feet of open earth at its base. In Washington, D. C., the regulation openings are 3 feet by 8 feet, or 24 square feet. (Plate II.) A generous space of earth about a tree is absolutely necessary for health. While a tree is young the soil in this opening should be stirred frequently to admit air and control evaporation; after it becomes of good size grass may be allowed to cover the opening although constant cultivation will stimulate growth.

Tree roots need air.

In summer if rain does not fall for several weeks the tree should have water, for pavement, sidewalk and house fronts become so heated that the evaporation from the leaves is greatly increased. Unless the water thus drawn off is replaced the tree suffers. A thorough saturation of the soil every week or ten days is better than more frequent sprinkling. A good plan is to build an earth dam about the tree, three or four feet from its base, or as near that as the pavement will permit, and fill the enclosed space with water, several times if necessary. When the water has all been absorbed, and the top soil is dry, break down the dam and spread the pulverized earth over the wetted area. That will retard evaporation. Be careful not to water so frequently that the earth becomes soggy and sour.

Plenty of water.

Trees need food as much as animals. In the forest they get what they require from the decaying leaves and other litter; along unpaved roads they usually are fertilized from the organic matter washed into the gutters, but on paved streets all this is gathered up and taken away. This deficiency can easily be supplied, however, by a little old stable manure spread over the open space in spring and worked into the soil with a fork or rake, or it can be heaped about the tree over winter and removed in the spring. If the exposed manure is objectionable a commercial fertilizer may be substituted. For light soils mix equal weights of nitrate of soda, acid phosphate, muriate of potash, and ground bone and apply in the spring at the rate of from 1 to 1½ pounds of the mixture to 100 square feet of exposed soil. This equals from 1¼ to 2 ounces for a tree with a footing of 8 square feet. For heavy clay soils mix 2 parts nitrate of soda, 3 parts acid phosphate, 1 part muriate of potash, 2 parts bone meal. Apply at the same rate as the above. In either case distribute the fertilizer evenly and mix it thoroughly with the soil. Be careful not to use too much else the tree roots may be burned. Where it is inadvisable to break the sod, or to work the soil, beneath a tree make holes with a crowbar about six inches deep and two or three feet apart and fill them with this mixture.

Feed your trees.

The task of nourishing a tree properly is not so simple as these instructions seem to make it, but nothing more specific can be said without considering the natural soil and the kind of tree. The essential point is that trees need nourishment and need reasonable care. Thin foliage, slender branches, and dead tops (commonly called stag-head) are all signs of starvation and must be heeded or the whole tree will die.

Fig. 9. Such exposure of roots is bad, but may be tolerated until a new tree can be established.

INJURIES.

All street trees are subject to injury of many kinds other than those against which ordinary guards are provided.

It is the duty of every owner who occupies space on the sidewalk to maintain a *good* tree, to co-operate with his neighbors, the Shade Tree Commission or other local authority, and with the public service corporations that also use the streets, to the end that injuries of every kind may be avoided or promptly remedied.

The principle that shade trees have a direct bearing upon property values is well established in this State, and one who suffers loss can recover far more than the wood value of a killed tree or the cost of a new one. Nevertheless contests should be avoided, and in the following pages an effort is made to show how all interests can be harmonized as well as how various kinds of injuries should be treated.

Value of trees.

CONSTRUCTION AND BUILDING.

Shade trees have no proper part in any construction work, whether of street, sidewalk or building. When they stand near by provision must be made to secure them against injury, otherwise they are sure to be damaged. Most of the things to be looked after may be summarized as don'ts.

Don'ts.

Don't allow any guy wire or rope to be fastened to a tree. But if this cannot be avoided be sure that the tree is amply protected by wood blocks as shown in Fig. 11. A pretended guard of sacking as shown in Fig. 10 is of no value.

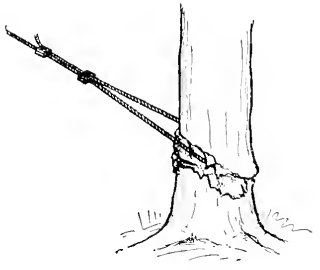

Fig. 10. A tree choked by a guy wire.

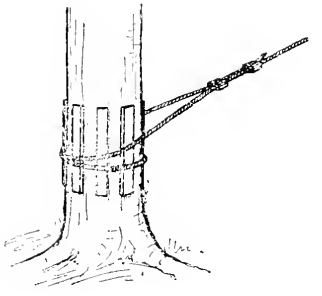

Fig. 11. Guard a tree thus if it must anchor a guy.

Don't allow a tree to be used as part of a scaffold; it can always be avoided.

Don't allow bricks, stone or any building material to be piled against a tree unless strong wooden guards are placed about it. See Fig. 12.

Don't allow piles of sand, stone, etc., to stand long about the base of a tree; such material will rob the roots of air the same as a close pavement. See page 24.

Don't allow a mortar bed where water saturated with lime can flow from it to the ground about a tree; the roots cannot stand it.

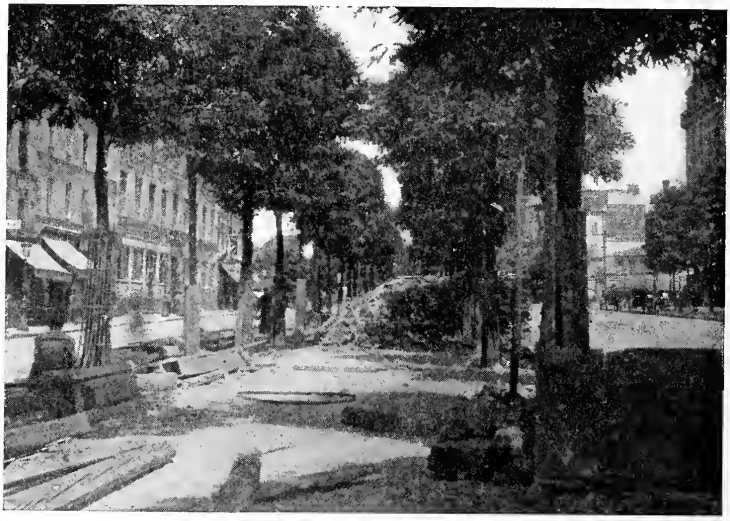

Fig. 12. Every tree well guarded against injury while building goes on. Paris. Photo by Dr. W. A. Murrill.

SALT.

Salt in excess is fatal to tree roots. Be careful if it is used to melt ice on the sidewalk, and don't allow brine from an ice cream tub to be emptied near a tree.

GAS.

Illuminating gas from defective mains is a common cause of injury to street trees. Other gases, especially sulfurous acid, when discharged into the air in large quantity may damage or kill them, but this happens only near chemical works and under conditions not at all common. If a buried gas pipe is not perfectly tight the escaping gas poisons the soil about it and affects nearby trees more or less seriously in proportion to the quantity of gas discharged into the soil penetrated by the roots. Thus, other things being equal, the nearer a tree is to a leak, the greater the danger that it will

be killed and the quicker the poison will act. Conversely a small leak, or one at some distance from a tree, may induce so slow an action that the real cause of the tree's failure cannot be determined. The activity of gas poison depends also upon the character of the soil, the material of which the road and sidewalk are made, the species and the vigor of the tree. For instance, clay soil will allow gas to escape from it less quickly than sand, but if the road surface above it is gas tight tree roots in either will have little chance.

Locating a leak.

Not infrequently an actual leak can be located by observing that trees and other vegetation are affected with variable severity within a circle having a radius up to one hundred feet. The source of the trouble will be found near the center of the circle and near the tree that suffers most. A poison case may develop so rapidly from a large, sudden leak that several trees will be killed within a day or two. Ordinarily, however, leaks are small and the poison spreads slowly. Sometimes only a part of a single tree is affected.

Signs of gas poison.

But it is often difficult to establish a case of poison because most of the evidences may be produced by other causes. If, however, the leaves develop less size than usual, or wilt after they unfold—usually beginning at the ends of the branches—or if they droop suddenly in mid-season, a gas case may be suspected. Later and surer signs are dark blue stains in the inner bark. These stains will often be found in the roots when they do not appear in the body. Loosening of the bark usually follows death, whether gas or something else be the cause. One who is not expert should hesitate to declare a case of this kind. The odor of gas is the surest guide to its presence. If that, or a failing tree, indicates a leaky main drive a crowbar three feet into the ground as nearly as possible over the joint that may be faulty. Then withdraw it and put your nostrils to the hole. Don't try with a match for that may cause an explosion. If gas is present lose no time in having the leaky joint, or joints, exposed and made tight. Where trees are endangered it is important to free the soil of poison at

once. Ordinarily all this will be done by employes of the gas company if the case is reported directly to headquarters, for any gas company wants to avoid claims for damages on account of leaks. It also wants to stop the loss that leaks occasion. It is possible to make this positive statement because gas superintendents in this State have repeatedly sought advice of the Forest Commission, or of Shade Tree Commissions, have followed the recommendations made, and in numerous cases have settled claims for damage on the basis of the opinion rendered. The Forest Commission is always willing to help adjust differences of this kind provided both parties wish it and agree to accept the forester's decision.

Report to Gas company.

How to save a tree.

If a tree has been poisoned by gas, but is not killed when the leak is found and stopped, it may sometimes be saved by digging a trench about it, on the gas side at least, as deep as and including the gas main and from six to ten feet from the trunk, and leaving the trench open for at least a month. If rain does not fall plentifully water the earth about the tree roots. This will give the confined gas a chance to escape. Of course care must be taken that the tree is not so dug out that it will be overthrown, and that the earth from the trench is thrown away from, not towards, the tree. All this may be difficult in a crowded street, but is the only remedy. If the tree shows signs of reviving let the out-thrown soil be worked over several times and thoroughly aerated, or better carted away and replaced by fresh, then fortified by one-fifth its bulk of well rotted compost and the trench filled up. Stimulate the tree further by a top dressing spread within the trench line as advised on page 25. In some cases a severe pruning of the crown will aid recovery by reducing the strain on the root system. Unless a tree is dry and has no signs of life in buds or stem don't conclude that it is dead until it has passed a summer after being affected. Nature is full of resources, and often seems to make light of serious injuries. On the other hand spring sometimes gives a semblance of life to a tree that is actually

dead by developing winter buds into foliage that is apparently normal.

When a tree is dead remove it, and before planting another in its place change the soil or freshen it as directed above.

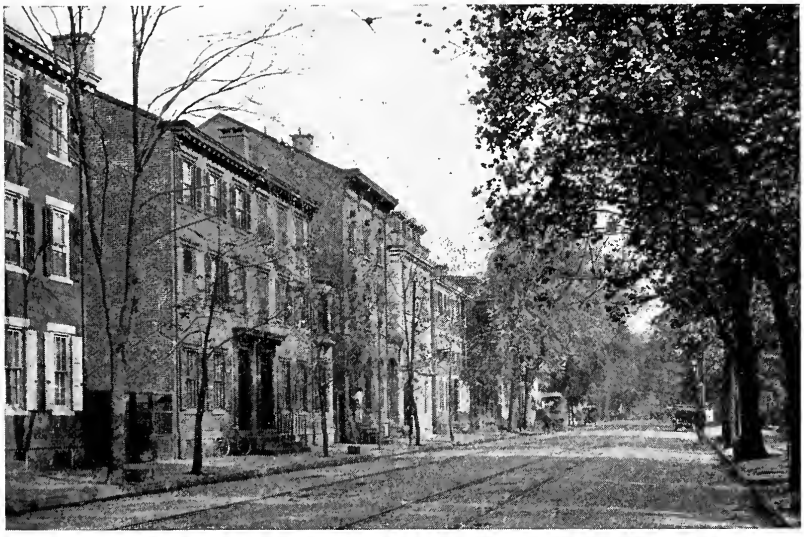

Fig. 13. How lack of system gives a poor effect. Trees of all kinds, shapes and conditions. Contrast Figs. 1 and 4.

ELECTRIC WIRES.

Rarely harmful.

Contrary to the common belief electric wires are rarely directly harmful to trees. They are objectionable chiefly because the workmen who look after them are careless or indifferent and do unnecessary damage. The current in a telephone wire is too weak to be injurious under any circumstances, while a lighting wire carrying an alternating current will injure the living tissue of a tree only when wet weather and the loss of insulation make possible a close contact. Most of the injury done to trees comes when a high tension direct current escapes, as from a trolley feed wire, and burns the tree at the point of contact or is grounded through its trunk.

Alternating and direct currents.

In the latter case a tree may be killed as by a lightning bolt. But injuries of this kind are too rare to require special consideration. Moreover, the management of no electric company will long neglect a contact that means a loss of energy in its lines.

Underground wires not practicable everywhere.

It will be admitted that overhead wires are objectionable in any organized community and should be put underground wherever it is practicable. Let every effort be made to extend the territory within which all wires must be carried out of sight, but at the same time let the facts as they affect most tree interests be not forgotten. These are that electric service is indispensable, that the electric companies have certain defined rights in many streets, that private, municipal and corporate interests are more often served by agreement and compromise than by contest. And it is always easier to adjust a matter of this kind before a franchise is granted, or before work is begun, than after an installation is in place. The following suggestions may help to resolve various difficulties in connection with shade trees:

How to harmonize tree and wiring interests.

1. If wires are to be extended to a street not previously served, seek by agreement to have the poles set behind the houses rather than in front. This is often difficult, as where the street lights are on a high tension circuit while the houses are served from a low tension, or it may be impracticable for other reasons. Nevertheless it can be accomplished in some cases, especially if the property owners are reasonable with respect to allowing linemen free access to the poles, and provision is made for crossing intersecting streets.

Wires back of buildings.

2. If wires are to be run on a shaded street where they have not been before, try to have the poles set on one side or the other of the tree line, preferably next the curb. (See Fig. 14.)

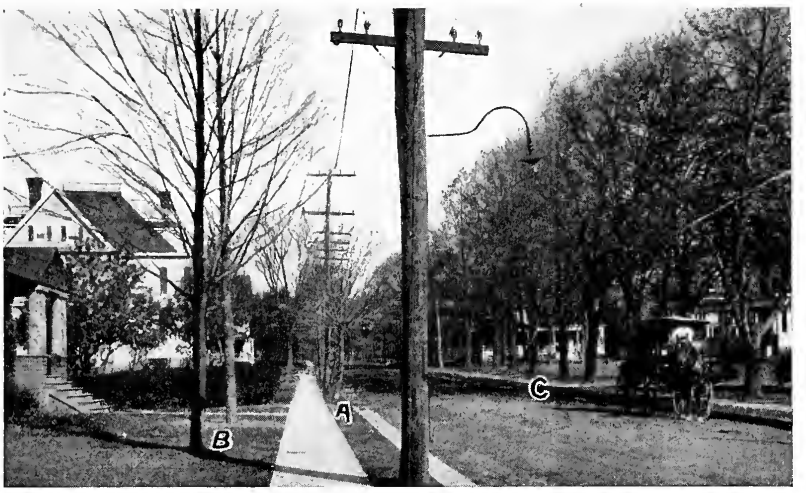

Fig. 14. Trees on curb, A, must compete with electric wires. Those inside walk, B, have head-room. Note fine row, C, protected from street by sidewalk.

3. If lighting wires must be run with a line of trees consider whether they shall be carried on high poles over the trees, on crossarms projecting into the street, or through the bodies of the trees. The chief objection to the first plan, next to its unsightliness, is that the growth of the trees will almost surely bring the upper shoots into contact with the wires and thereby cause them to be broken and the tree crowns distorted. At the same time the wires will be disturbed, and the current perhaps grounded. This is rarely a good plan. Carrying wires on projecting crossarms is objectionable because it interferes with the freedom of the roadway, and looks badly. The device should be resorted to only in exceptional cases. As a rule it will be found most practical and most satisfactory to carry wires through the bodies of trees and quite low down. They must be insulated, of course, but when that is done properly the trees will not be injured and the wires themselves will be less disturbed by the normal tree movements. Trolley feed wires

Wiring above or around trees.

Wiring through trees.

should always be properly insulated and carried as low down as is practicable.

Wires in cables.

4. Telephone wires should always be carried through the lower portions of trees, and when there are several be united in a cable. (See Fig. 15.) It is not practicable to cable high tension wires.

Fig. 15. Old trees C, D, E, on a new grade and with cabled wires through their crowns. New trees should be planted at X, X, X, and when they are grown the old ones removed.

Plant low trees.

5. If trees are to be planted in a street where the only available room is already occupied by wires, that is a street with little space between the curbs and building lines, there are just three courses open: *one*, to induce the electric company to remove the wires before the trees are set; *two*, to get an agreement that they will be removed or raised at a fixed time in the future, or when the trees shall have grown so that tree shoots and wires interfere; *three*, to plant low growing trees and by pruning keep them below the wires. The last is often a good plan, as big trees are out of place in a narrow street.

Damage done by linemen.

With respect to the damage done by linemen there is now less ground for complaint than there formerly was. Nevertheless such men will bear watching, and should be given to understand that they will be held responsible for any injury. There is ample law and precedent in the State to prevent injury in this way, as well as to secure redress if the property owner will trouble himself to protest and, if necessary, to prosecute his claim. It will not often be needful to go further than to make a formal complaint or claim; corporations dislike litigation and will satisfy any just demand. Two points only need be observed: 1. Forbid absolutely the use of climbing spurs; they are unnecessary in tree work, and every time they break the bark give disease germs a chance to enter. And forbid a workman to go into a tree, even by a ladder, with his spurs on; they will damage the bark on the branches. 2. Require the man in charge of the work strictly to observe the rules of the National Electric Light Association. These rules have been adopted by most of the telephone, telegraph and lighting companies, and in themselves prove that the officials are ready to do their share to avoid trouble. The most important of the rules are: *

Law enough to guard all interests.

"11. Wires shall be strung on the side of the street most free from trees."

"66. Guy wires shall not be attached to trees without the permission of the owner or other proper authority."

"68. Tree trunks and limbs shall always be protected from injury by the use of tree blocks between the tree and the wire attached thereto."

"83. Line wires shall not be supported upon trees."

Wiring rules.

"89. It is essential for the safe and uninterrupted operation of lines that they be free from possibility of grounding on trees. It is therefore important that tree branches interfering, or likely to interfere, with the lines should be cut away. Such trimming must be done with care and judgment, and under the supervision of the superintendent, line foreman, or other responsible person."

*From report of Committee on Overhead Line Extension. New York, June 2d, 1911.

"90. Before any trimming is done the consent of the owner of the tree should be obtained.* Opposition to tree trimming may sometimes be overcome by offering to employ a professional gardener for this purpose. If consent to trim trees cannot be obtained, and the interfering branches cannot be avoided by the use of longer crossarms, or by offsetting the standard crossarms, tree wire shall be used."

"91. The stubs of branches shall always be painted for their protection and to make them less noticeable."

"94. Where tree wire is used, if there is danger of limbs or large branches chafing the insulation, it shall be protected by means of wooden abrasion moulding."

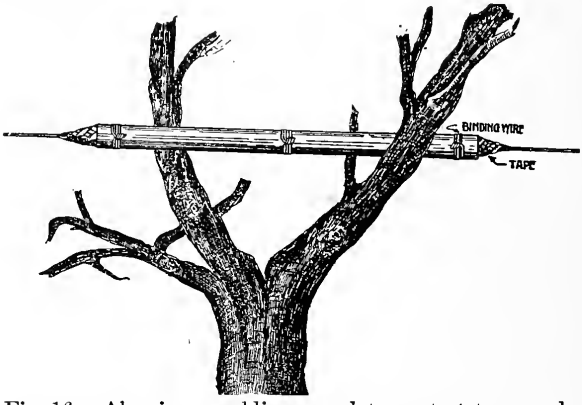

Fig 16. Abrasion moulding - used to protect trees and wires. (Courtesy of National Electric Light Assn.)

INSECTS, DISEASES.

These subjects are presented fully by Dr. Smith and Dr. Cook in their accompanying papers.

ABRASIONS, HORSE BITES.

A tree whose bark is broken is hastened towards an early death. Prevent such injuries by guards and by police regulations. Be particular about the lawn mower. Half our shade trees are repeatedly bumped and permanently injured through wounds made at their bases. (See page 54.) If a tree is so damaged have it treated promptly as directed on page 44 and Fig. 20.

*Where there is a Shade Tree Commission it has authority above the owner and will help to adjust differences.

PRUNING.

Under normal conditions a tree needs little or no pruning but, at least until it gets ragged from age, is best left to develop its natural form. Shade trees, however, frequently require pruning to adapt them to their surroundings and to maintain a healthy growth. A tree does not develop at random but after its kind and with reference to the stimulants and checks that are brought to bear. One of the most important of these influences is light. Light has a direct influence upon the form and health of a tree. The strongest growth of a tree's branches is made toward the brightest light. The parts of a tree which for any reason are shut off from the light weaken and sooner or later die.

Light.

Fig. 17. Norway maple with characteristic dense crown. The foliage developed on this drains the roots in dry weather and weakens the tree.

Fig 18. Norway maple after an interior pruning. This modifies the shape of the tree in no way while reducing its leaf area and thereby increasing its vigor.

PRUNING FOR VIGOR.

Street trees must be made to develop so that they will not interfere with traffic, and in such a way as to make the best use of existing light conditions. This is accomplished by pruning. Subject to differences necessitated by abnormal conditions, a tree which has been skillfully pruned for a number of years will approximate the following description:

1. There will be a primary frame consisting of from one to three axillary branches, the number depending upon the species. A tulip or pin oak will have a single axis, while an elm or maple will have two or more co-ordinate members.

A properly formed tree.

2. Grouped about the primary frame will be several less imposing branches so arranged as to form a symmetrical frame work and characteristic of the species.

3. Each branch and branchlet will be free from physical contact with its neighbors.

Unless the tree has had proper care from the time it was planted it will fall far short of this ideal, and quite heroic methods may be necessary to overcome the neglect of years. The commoner rules for pruning may be summarized as follows:

AT THE TIME A TREE IS PLANTED.

1. The object of pruning at planting is to make the tree live. If it is necessary to sacrifice form to secure this result, do so. After a tree is thoroughly established its growth to the proper form can always be accomplished.

Pruning for life.

2. If the roots are intact it is not necessary to prune the crown. It is seldom, however, that such is the case, and the removal of from twenty-five to fifty per cent. of such branches as are not needed in the shaping of the crown will be a wise precaution to counteract root injury.

3. If any of the roots are broken remove the injured parts by making a clean cut. Balance this cutting by removing a slightly greater relative proportion of the crown. Sometimes it will be necessary to remove practically the entire branch system to obtain a proper balance. (See Figs. 6, 7 and 8.)

WHEN A YOUNG TREE IS FULLY ESTABLISHED.

1. Select the primary frame according to the growth habit of the species in hand.

2. Select several secondary branches which either do, or can be made to, conform with the primary frame in harmonizing the shape of the tree. **Pruning for form.**

3. Remove any of the larger branches which do not conform to the general character framework.

4. If the primary frame is vigorous enough to maintain its domination over the secondary development, simply remove the smaller interior interfering branches.

5. Curtail any of the main branches which threaten to assume undue proportions by removing a part of their terminal growth.

WHEN A TREE IS WELL DEVELOPED, BUT UNPRUNED.

Most trees of this class will carry a considerable burden of dead wood in their interiors, and a large amount of half suppressed and vigor-lacking growth throughout the mass of branches. There is usually considerable irregularity in the form of the tree due to the greater vigor in some branches than in others. (See Fig. 17.)

1. Remove all dead wood.

2. Select from the most vigorous branches the character framework as outlined above. **Pruning for vigor.**

3. Remove all branches large or small which do not fit in with the scheme of form development decided upon.

4. If the primary frame does not distinctly dominate, curtail the secondary development by clipping the terminals.

5. If necessary to cut back any large branch by a considerable amount without entirely removing it, leave a vigorous small branch near the point where the cut is made to act as a "sap lifter" and thus insure the life of the branch which has been shortened.

6. Establish an individuality in each branch by removing from it such parts as would bring it in contact with its neighbors, or which grow contrary to the characteristic habit of the species.

7. Remove internal decay as indicated under "Treatment of Cavities," page 45.

WHEN A TREE IS NEGLECTED AND DECADENT.

Old untrimmed trees always contain broken branches and much dead wood, and frequently possess certain branches which have grown disproportionately. This irregular growth and mutilation often develops a picturesque appearance which should be retained unless there is some outweighing reason for altering it. Under no circumstances allow a tree to be "topped," that is, reduced to a post with branch stubs at the top. Fig. 19. Under any but exceptional conditions the practice is butchery. Better take the tree away and plant a new one. "Heading in" is another matter, and if carefully done may cause a decadent tree to recover its form as well as its vigor.

"Head in" but don't "top" a tree.

Fig. 19. Butchered maples. Not necessary to escape the wires and in no way justified. The winter aspect of a tree is almost as important as its summer aspect.

An old tree if moderately sound will stand, and be thankful for, any reasonable treatment of its crown. In a case of this kind observe the following:

1. Remove all dead wood.
2. If all the large branches must be cut back make at least two operations, a year or more apart.
3. Make the cuts so that the stubs of the "headed in" branches will roughly conform to the desired shape of the crown to be.
4. Be sure that a small "sap lifter" is left on each shortened branch near the place where the cut is made.
5. Treat all decay as directed under "Treatment of Cavities," page 45.

How to Prune.

In removing a branch it is important to make the cut close to the trunk, or remaining branch, and to take such precautions as will insure a clean wound without injuring the surrounding bark. An ordinary hand saw or a pruning saw is generally used. Unless the branch is quite small saw underneath first and finish from above. This is to prevent the splitting down of the branch, or breaking the surrounding bark. In removing any sizable limb, make first a half cut from the under side and about a foot from the trunk; then sever the limb entirely by a cut a few inches further out. (Fig. 20 B.) The object of the undercut is to prevent the inevitable split from running back to the base of the branch. Finally remove the stub close to the trunk. If a limb is very large and heavy, and there are other branches beneath, support it from above by means of ropes in order that it may not fall and do damage. Be sure to make the final cut as close to the tree trunk as possible, since a large wound there will close in a more satisfactory manner than a smaller one at the end of a short stub. And be especially careful that as the severed limb finally falls the bark next its underside is not torn from the tree.

Avoid splitting.

Cut close.

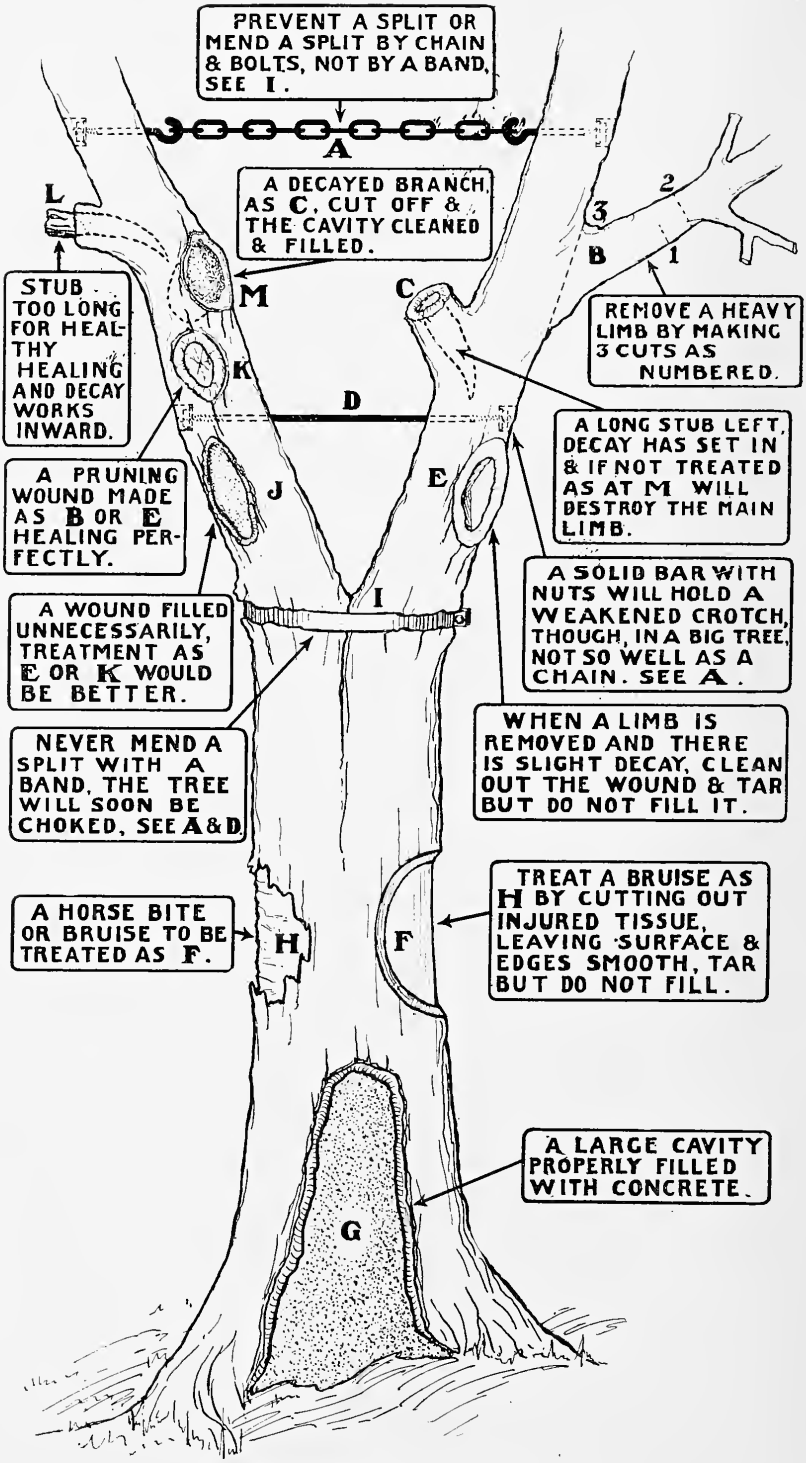
PREVENT A SPLIT OR MEND A SPLIT BY CHAIN & BOLTS, NOT BY A BAND, SEE I.
A
A DECAYED BRANCH, AS C, CUT OFF & THE CAVITY CLEANED & FILLED.
L
M
C
K
D
J
E
I
B
1
2
3
STUB TOO LONG FOR HEALTHY HEALING AND DECAY WORKS INWARD.
A PRUNING WOUND MADE AS B OR E HEALING PERFECTLY.
A WOUND FILLED UNNECESSARILY, TREATMENT AS E OR K WOULD BE BETTER.
NEVER MEND A SPLIT WITH A BAND, THE TREE WILL SOON BE CHOKED, SEE A & D.
A HORSE BITE OR BRUISE TO BE TREATED AS F.
H
F
G
REMOVE A HEAVY LIMB BY MAKING 3 CUTS AS NUMBERED.
A LONG STUB LEFT, DECAY HAS SET IN & IF NOT TREATED AS AT M WILL DESTROY THE MAIN LIMB.
A SOLID BAR WITH NUTS WILL HOLD A WEAKENED CROTCH, THOUGH, IN A BIG TREE, NOT SO WELL AS A CHAIN. SEE A.
WHEN A LIMB IS REMOVED AND THERE IS SLIGHT DECAY, CLEAN OUT THE WOUND & TAR BUT DO NOT FILL IT.
TREAT A BRUISE AS H BY CUTTING OUT INJURED TISSUE, LEAVING SURFACE & EDGES SMOOTH, TAR BUT DO NOT FILL.
A LARGE CAVITY PROPERLY FILLED WITH CONCRETE.

Fig. 20. Diagram—How to doctor a tree.

SUGGESTIONS.

Ever-greens.

Do not prune evergreens, except hedges, unless the severed member is wanted out of the way. Evergreens do not sprout from cuts as do most deciduous trees.

Time to prune.

Pruning may be done at the most convenient time unless the wound bleeds. As this is most likely to occur in spring that season is the least advisable. Fall or winter is usually best, for then the sap is least active and the leaves do not obscure the tree framework.

Do not remove a live limb unless it interferes with a better one or otherwise fails to meet the form and health requirements of the tree.

Excess of foliage.

Interior pruning is often necessary in the maples, basswood, and similar dense-crowned trees, because the foliage develops beyond the power of the roots to satisfy it with water. A treatment similar to that ordinarily given fruit trees is advised. (See Figs. 17 and 18.)

The suckers or long shoots from adventitious buds, often observed on elms, give them a peculiar beauty not found in other common shade trees. Spare these instead of removing them as is often done.

Tree Fakirs—Warning.

Do not trust your tree work to the first man who comes along, but seek a reputable worker. No chestnut tree can be cured of the blight; a wound badly filled or unnecessarily filled would be better left open (Plate III); and a tree that is sprayed carelessly or with wrong material will be benefited as much as, and no more than, one that is butchered under a pretence of being pruned.

Tree owners are warned against men without credentials, and those who have work of this kind to do are advised to seek assistance from the local shade tree commission, or, if help cannot be secured in that way, to apply to the Forest Commission, to the State Entomologist or to the State Plant Pathologist.

CARE OF WOUNDS.

Fig. 21. Four branch wounds with good calluses but each showing a cavity, the result of long stubs and lack of treatment to prevent decay. See Fig. 22.

Every break in the bark of a tree should be treated with an antiseptic to prevent the entrance of decay. But this rule is commonly ignored in so far as clean cut wounds, not over two inches in diameter, made in the live wood of a healthy tree, are concerned. But every pruning wound of larger size must be treated else decay may set in before it can heal over. (Figs. 21 and 22.)

Tar all wounds.

The treatment consists simply in painting the exposed wood with coal tar, creosote, or lead paint. The first is usually preferred. Thin the tar by heating it if necessary and apply with a brush, being careful not to cover the cambium, or tissue between the wood and bark. Give two good coats and repeat every year or two until the wound is completely healed.

Wounds due to mechanical abrasion or animal gnawing should have all the injured wood and bark removed with a knife or gouge and then be treated as directed above. (See Fig. 20.) If the bark is merely scraped but not broken through, let it alone and see that it "does not happen again."

Fig. 22. A group of branch wounds perfectly healed, no filling needed as stubs were cut short and wood was sound. See Fig. 21.

TREATMENT OF CAVITIES.

1. Remove as much of the decayed wood as the location of the cavity and the condition of the tree seems to warrant; aim to expose a smooth surface of sound wood at all points.

2. Sterilize the surface by a brush application of copper sulphate or creosote.

3. Give the cavity at least three coats of coal tar, avoiding covering the cambium.

4. If the cavity is of such shape that it will catch and retain water, or if it is so large that the tree is weakened thereby, fill it as directed below.

5. If the cavity does not fall in either of the above classes it is best to allow the natural growth of wood to gradually cover over the defect.

PLATE III.

TREE WOUNDS HEALING WITHOUT, AND IN SPITE OF, FILLING.

A. A bad scar on a fine elm healing perfectly without cement.

B. New growth on a wounded elm which has forced out a cement filling.

C. New growth closing another wound on the same tree and confining some of the cement.

D. Strong new growth closing a bad scar that would have been better left without brick or cement.

E. A fine callus closing a bad wound on a hemlock that has had no treatment. The decayed wound in center should be removed and the sound core tarred.

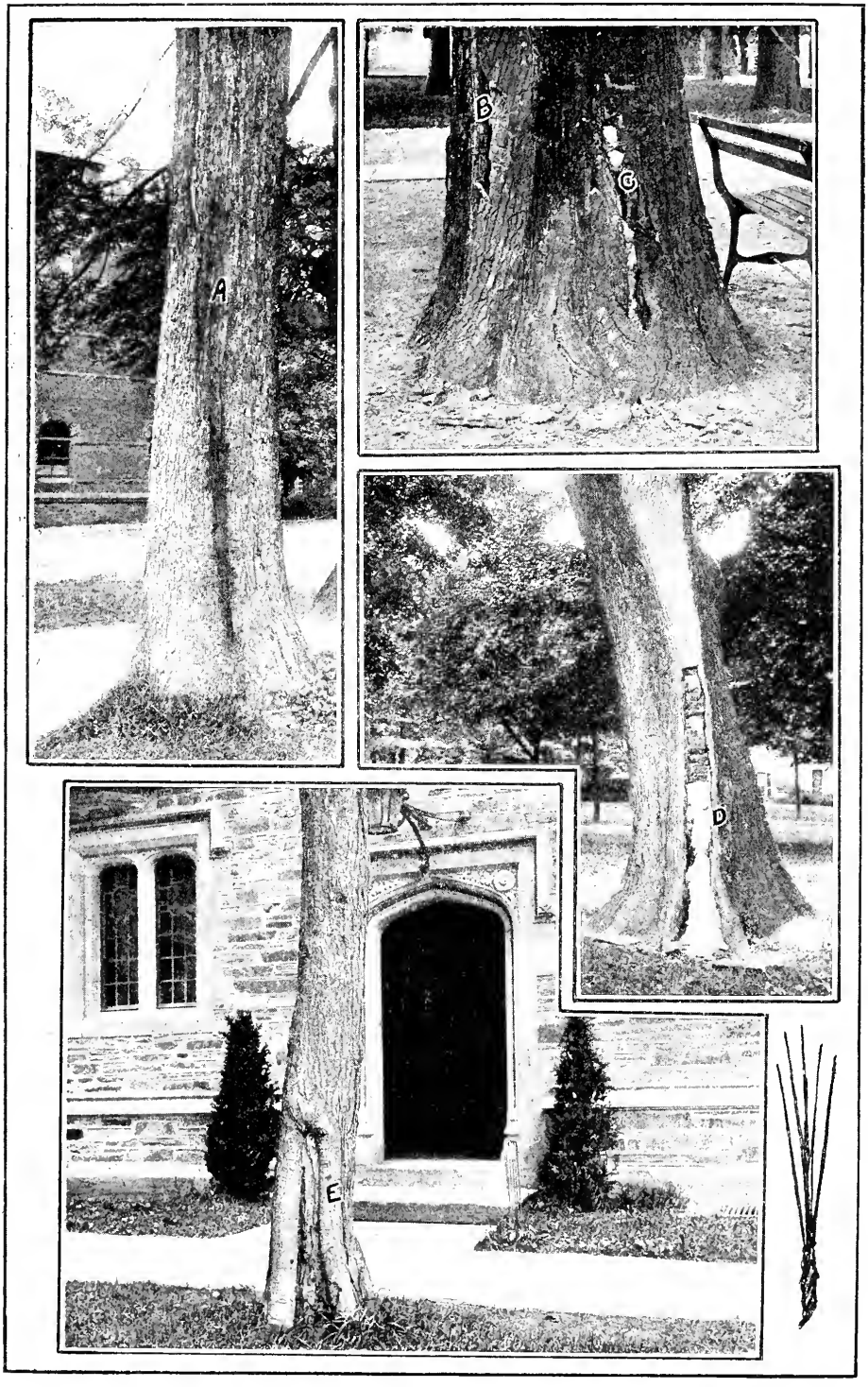

Plate III. See opposite page.

A word of warning must be given against the too free use of cement or concrete in treating trees. The material undoubtedly has value in spite of a lack of elasticity that almost inevitably prevents a filling from being water tight, or causes it to crack and fall out of place. It may always be used where a tree needs mechanical support, often where a cavity is unsightly, and sometimes to keep out rain. Under other circumstances it usually is best to clean and treat antiseptically a cavity, certainly a superficial or shallow wound, and leave the rest to Nature. In many cases a filling secretes rather than excludes moisture, thereby inducing decay, and unless it is very carefully made may interfere with the normal processes of repair. (See Plate III.)

Don't use cement too freely.

Where a cement filling must be made a few rules will serve to guide:

1. Prepare the cavity as above and in addition remove the bark around its edge for about half an inch. This is to expose active cells in the cambium from which the healing callus may develop.

2. Fill the cavity flush with the wood at the edge of the opening but do not lap over. If desirable the cement may be sculptured to resemble bark.

3. A small cavity may be filled with pure cement. For large ones use a concrete consisting of one part cement to two parts of sand and reinforced with stone, brick or iron. Cover the exposed face with an inch of pure cement. Spikes driven into the wood inside the cavity will help to hold the filling in place.

Cement or concrete.

Another method is to cover the cavity with sheet zinc, carefully fitted and securely nailed to the exposed wood at its edge, and fill in concrete behind it. The concrete should be liquid enough readily to adapt itself to the interior of the cavity. This is a simple and very satisfactory way to get the filling in place and to keep it there. Of course the zinc must be first fastened at

Zinc facing.

the bottom and the concrete poured in from above. The zinc and the edges of the wound should be painted or tarred to render them less conspicuous.

BRACES FOR CROTCHES.

Acute angled crotches in trees of large size often split. To prevent this, or to repair a break, let iron braces be put in of size sufficient to withstand the strain. See Fig. 20. Do not let bands be used, many trees have been ruined by them. If the weight of limbs is not very heavy a solid rod with screw threads on both ends can be used. Ordinarily, however, it is best to use hook bolts and a chain, or eye bolt, so that there may be some movement when the wind blows. Whether a single rod or a combination is used let a neat hole be bored entirely through each limb and as high above the crotch as is practicable. If a rod is used these holes must be in line, if a chain or eye bolt it does not matter. On the outer side of each hole countersink a seat for a washer at least 4 inches in diameter and for the nut. When the brace is in place make the whole taut by screwing up the nuts. If the tree has been split and the gap cannot be closed by the power of the screws rig a tackle higher up. Let the hook ends of the bolts project several inches so that they will not be buried as the tree grows, but see that the washer, nut and end of bolt are left so that they will be overgrown.

Don't use bands.

Eye bolts or chains.

WHAT TO DO WITH OLD TREES.

Nothing that has been said about the choice of trees should be construed as a recommendation to remove a poor tree before it can be replaced by a better one. A ragged old silver maple is often better than none. When systematic tree planting is decided upon accommodate the plan to existing trees and provide for a *gradual* replacement of undesirables.

Old trees better than none.

In the meantime fix up the latter and help them to keep alive: cut out all broken and dead branches, heal the wounds and open the pavement so that the roots may have air. If necessary curtail the crowns gradually so that new trees adjoining shall not be hampered in their development. If a tree is very bad don't waste time and effort but replace it at once.

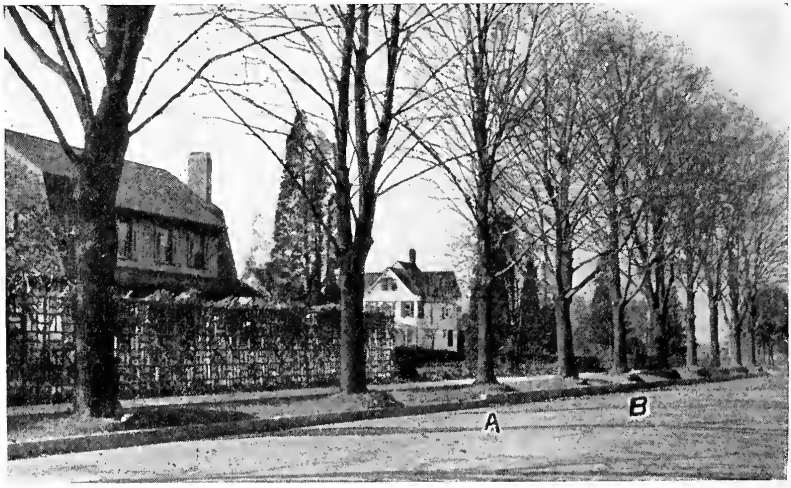

Fig. 23. Trees saved by mounding and raising curb when road was lowered. Note step in curb at A. Base of tree B is 30 inches above the gutter.

Where a change of grade has left a tree above the common level don't leave it to be kicked and battered by every passer-by, but cover the roots with a few inches of earth and provide some means to keep it there. (Fig. 15.) A slight change in a sidewalk may be fully justified by the necessity of saving a valued old tree. If a new grade requires a fill about a tree don't pile on two or three feet of earth at once, but build a well of brick or stone at least 3 feet greater in diameter than the tree stem. (Fig. 24.) Let that fill up gradually and occasionally break the bark on the tree, just below the soil level, to encourage the growth of new roots.

Fig. 24. A "Well" constructed about an elm tree when grade was raised. Photo by Wm. Solotaroff.

CO-OPERATION.

In few lines of civic work is co-operation so essential as in the care of shade trees. The fact that one individual ordinarily owns and controls but a fraction of the property in a block makes it necessary for each owner to work with, and not independently of, his neighbors. In almost every community the best results will be secured through a Shade Tree Commission, or a Park Board having similar authority.

Fig. 25. Street grade raised two feet without changing sidewalk or injuring trees. Practicable only on a side street.

SHADE TREE COMMISSION.

Where a community interest in shade trees has been awakened the best way to get things done is to organize a shade tree commission. The State laws give ample powers to such bodies and one properly supported by local ordinances and reasonable appropriations will soon change the sylvic aspect of a municipality. The only objection to the laws as they stand that is of importance concerns itself with the unusual powers granted a Shade Tree Commission. The answer is that in practice the laws have worked no injury or injustice but have enabled several communities to care for their trees systematically and effectively.

An individual may do the right things for the trees in front of his property and the community get the benefit, but ordinarily his interest is spasmodic and apt to be ineffective. He neglects to have his trees fed, or doctored, or trimmed, or he employs a butcher who spoils them. A shade tree commission can prevent abuses and require symmetrical planting, can doctor, prune and spray, can make terms with the gas company and electric company and save the owner all trouble. Some property owners do not want to give over to a public body the care of trees which they have planted and nurtured. The position, though understandable, is unreasonable in a day when utilities and conveniences are developed for the advantage of the public. As well might each property owner insist on being allowed to do as he pleased respecting sidewalks, curbing, sewers. If every owner must dedicate a part of his property to the public for these purposes, he can quite as reasonably yield the care of his shade trees that his neighbors as well as himself may be benefited. An active Shade Tree Commission can do much good also by anticipating municipal improvements and harmonizing various interests. Where streets are repaved or grades changed an agreement with the engineers will save many an old tree from destruction. In not a few instances in this State has the want of co-operation, or co-ordination of duties and interests, deprived a town of trees that cannot be replaced. In new work the same unity is quite as neces-

Individuals not effective.

Plan for the future.

sary. Large open spaces about street trees, for instance, can be made only with the consent of those who regulate the pavements.

SHADE TREE FEDERATION.

The shade tree commission idea has progressed so far in New Jersey that an organization composed entirely of men and women actively interested in shade trees has been formed. It is in no sense a popular body, but devotes itself to problems that concern the various communities and their shade trees. In general it aims to be a sort of clearing house through which the experiences and needs of each community or Shade Tree Commission can be made to serve all their fellows.

Lawn Trees.

The variety of lawn trees that may be grown in this State is almost unlimited. And here evergreens are quite as valuable as deciduous trees. For the main features of any planting plan the same species recommended for street planting will be found most satisfactory; for contrasts, for pure ornament, for windbreaks, many other kinds are available. Individual taste will govern in this and there is no objection to trying novelties. There are many native trees, however, that are rarely seen but which well deserve place. Serviceberry, dogwood, several birches, various magnolias, red bud, silverbell, sourwood, yellow wood, mountain ash, hawthorn, larch, cypress, arborvitæ, hemlock, are all suitable, especially for sheltered situations. Many nurserymen are now prepared to furnish well grown trees and will guarantee them to live. Thus it is quite possible to give an air of age to a new place within a very few years. Of course the cost of large trees is considerable.

Many species possible.

Trees on a lawn should be planted and cared for the same as street trees, though they will ordinarily need no guards and may easily grow much more rapidly. For several years after a tree is planted, no matter what its size, grass should not be allowed to grow about its base, but the ground kept open and frequently cultivated and watered. After the tree is fully established a turf may be allowed to form, but it will still need to be fertilized because

Must be fed.

its natural food, the fallen leaves, dead grass, etc., will have been removed. Open earth at the base of every tree is recommended because, apart from all questions of nourishment, the bare circle acts as a guard against injury by lawn mowers, etc.

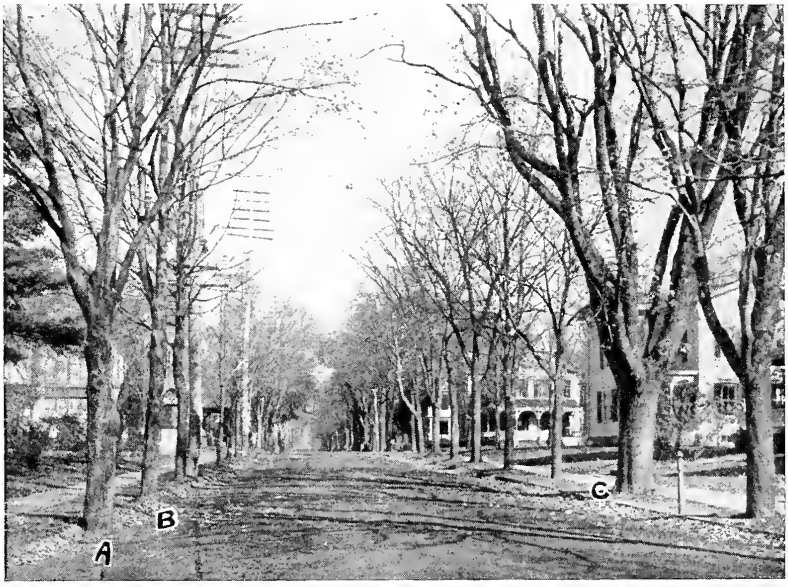

Fig. 26. Tree A stands in the gutter, Tree B in the curb line, Tree C is partly on the sidewalk. No harm done.

It is well to observe several points about the qualities and behavior of trees. Those which give a dense shade are usually shade-enduring or tolerant; they carry their own lower branches for a long while but kill or stunt trees, shrubs or grasses that are intolerant or light-requiring. On this account grass does not grow well under a beech or spruce but may under oak or pine. Sugar maple will do fairly well in the shade of elm, but elm is hampered by sugar maple. Trees grow tall and slender when crowded, much broader when they have plenty of room.

Shade enduranee.

All trees do best in good soil, but some, as most of the pines, require it loose and well drained. Others like elm, ash and pin oak favor moist locations.

Evergreens, especially spruce, balsam, cedar, arborvitæ, make the best windbreaks and permanent shade, but they should not be planted close to the house for they cut off the sunlight in winter when it is wanted. **Windbreaks.** Thin foliaged trees like elm, oak, sycamore, ash, are best in such places.

Seashore Trees.

Whether on streets or lawns, trees planted near the sea are subject to two great handicaps not commonly found elsewhere, namely, strong, constant winds and sterile soil. Close to the beach salt spray often works injury. These conditions make it imperative to plant only the hardiest species, though if great care is taken to prepare large beds of good earth sheltered lawns may enjoy a comparatively great variety. Especial pains must be taken to anchor every planted tree against the wind, for the breezes of summer are as nothing compared with the storms of winter which it must withstand. In any case many trees will be permanently inclined or distorted as are those that grow wild. **Shield from winter winds.**

Fig. 27. A well shaded lawn made from native forest near the sea.

On lawns the native pines, oaks, cedar and holly should be encouraged. Though of slow growth under natural conditions cultivation and care will stimulate them. The maritime pine (*Pinus pinaster*) of Europe is worth trying in exposed situations. Spruces and firs need protection.

Plant only approved species.

For street planting it will be best to try few experiments, but use the trees that are proven hardy and give them every care. The species most likely to thrive are sycamore, ailanthus, pin oak, scarlet oak, red oak, chestnut oak, hackberry, honey locust, red maple. Poplars and silver maple will be very short lived. Norway maple is apt to burn by reflected heat.

It is unfortunate that so little systematic or careful tree planting has been done in our seaside communities. A little active interest, and time of course, would transform their bare, sunny streets to avenues of shade.

Specific Characters of the Most Available Trees for Planting.

AILANTHUS.

A tree (*Ailanthus glandulosus*, Desf.,), imported from Asia, of luxuriant habit and ornamental appearance. It grows with remarkable rapidity in almost any kind of soil and makes a valuable tree for wide avenues. It is not well adapted to narrow streets. The tree is objected to on account of the litter produced by its leaves and abundant fruit, its early defoliation, and especially the offensive odor of the male flowers. This last, however, is easily avoided by planting only pistillate trees, since male and female flowers are often found on separate individuals. The tree is remarkably free from disease and insect pests and is well thought of in Paris, where it has been largely planted. It is a favorite in several cities in this country also, notwithstanding the error made by planting staminate trees in some cases.

ASH.

Of all the ashes, the white ash (*Fraxinus Americana,* L.) has the most desirable qualities as a shade tree. It requires a rich soil and does best in the presence of considerable moisture. Under favorable conditions it grows fairly rapidly and attains a good size with a moderately broad, open crown and thin foliage. It makes a desirable tree where a moderate shade is wanted in summer and much sunlight in winter. The tree has few enemies and is little subject to disease. The chief objection to it as a shade tree is that the leaves come late in the spring and fall very early. The European ash is less desirable than this. Green ash (*F. pennsylvanica, var. lanceolata* Sarg.) is a comparatively small tree but hardier than white ash. It is planted largely in the West and should have a place here on narrow streets and where only a moderate shade is wanted.

BASSWOOD OR LINDEN.

The most important species is *Tilia Americana,* L., a beautiful, large tree with compact crown, broad lustrous leaves, and a curious winged fruit. This is an admirable tree for avenues and streets of moderate width where sun glare is not excessive. On closely paved streets, and near brick or stone buildings, the tree suffers seriously from sunburn. Basswood requires good soil and considerable care. Where that can be given its beautiful foliage and fragrant flowers justify its planting. Under other conditions it should not be attempted. The European linden is apparently less able to withstand the trying conditions of city streets than the native species.

BEECH.

This tree has no value for street planting, but either the native species (*Fagus Americana,* Sweet) or the European (*F. sylvatica,* L.) makes a beautiful lawn tree. They require

rich, well drained soil and grow rather slowly. Under free conditions the tree is quite short but develops a broad heavy crown which casts a dense shade. There are many ornamental forms of the European species—as purple-leaved, cut-leaved and drooping. Many of the leaves adhere to the branches through the winter, a habit that some people consider a fault, others like the constant rustle of the dried leaves, as well as the appearance of the tree when most others are bare. This tree should never be planted where sunlight is wanted winter or summer.

Fig. 28. Beech. This and other trees grown on a lawn not sacrificed when street was cut through. Courtesy of Newark Shade Tree Commission.

CATALPA.

All the species of catalpa should be considered ornamental rather than practical shade trees. The southern catalpa (*Catalpa catalpa,* Karst) is a scrawny, irregular tree, but very picturesque in maturity, especially when covered with its large white bloom. The foliage and flowers appear quite late, and the leaves are blackened by the first frost or often attacked by fungi. The hardy catalpa (*Catalpa speciosa,* En-

gelm) grows more upright and is sometimes used as a shade tree, yet its large tender leaves, susceptible to frost as well as to burning by reflected heat, make it undesirable. The Japanese species (*Catalpa bungei* and *C. kaempferi*) are purely ornamentals of small size.

CHESTNUT.

This is a large tree of very rapid growth (*Castanea dentata,* Borkh), and formerly was one of the most valuable native species, but since the appearance of the bark disease (see page 101), not a single chestnut tree should be planted anywhere. The paragon, or large fruited chestnut, from Europe is advocated for its nuts, but it is apparently susceptible to the same disease.

ELM.

No other tree, native or foreign, combines so many desirable qualities for a street tree as the American, or white, elm (*Ulmus Americana,* L.) It grows too large for narrow streets, but for those of moderate width, and for avenues, it has no superior. The trunk commonly divides at from ten to fifteen feet above the ground and forms a broad, high-arching crown with pendent branchlets. The tree requires reasonably good soil and plenty of moisture, and under favorable conditions grows comparatively rapidly. The leaves are rather small and the shade produced not too dense. The autumn foliage is not notable. White elm is subject to several diseases, but throughout New England, and in this State, its chief enemy is an insect called the elm leaf beetle. (See page 67.) This, however, should not deter anyone from planting the tree for the insects can always be controlled. Slippery elm (*Ulmus fulva,* Michx.), and other native species have no especially desirable qualities as shade trees. The English field elm (*Ulmus campestris* L.) and the Scotch elm (*Ulmus montana,* Bauh.) are sometimes planted as ornamentals.

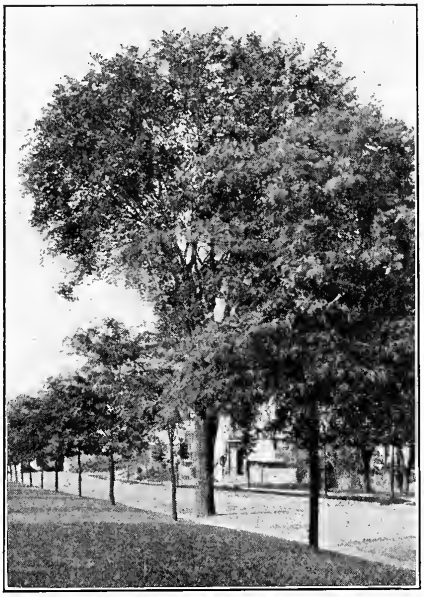

Fig. 29. Neither new road nor new trees require the sacrifice of a fine old elm.

GINKGO.

A tree (*Ginkgo biloba*, L.) introduced thirty or forty years ago from Eastern Asia. It grows rapidly on almost any soil, develops a narrow cylindrical or conical crown that adapts it well to narrow streets, and is apparently not affected by insects or disease. The fan-shaped leaves with straight veins are unlike those of any native tree and their bright coloring in the fall sometimes rivals that of the maples. The only objection thus far made to the ginkgo as a street tree is that its fruit, an oily nut, is sometimes malodorous. Even where the heat reflected from paved streets is considerable the tree thrives. It promises to be one of our most valuable species.

GUM.

Of the various gum trees only sweet gum, or bilsted (*Liquidambar styraciflua,* L.) is suitable for street planting. This, however, is one of the very best, since it adapts itself to many conditions, develops a symmetrical, narrow crown, and is most attractive throughout the year. The tree prefers moist, even wet ground, but grows fairly well under less favorable conditions. Extreme care must be exercised in transplanting as the roots are tender and lose their vitality if allowed to dry. The star-shaped leaves color gorgeously in the fall, and when they are gone the pendent spiky fruit heads adorn the tree throughout the winter. Many of the branches are furnished with curious corky ridges, or wings, sometimes upwards of an inch in width.

Sour gum, or black gum (*Nyssa sylvatica,* Marsh.), also called tupelo, and pepperidge, is a tree of quite different character. It grows under most adverse conditions, but is apparently not well suited for street planting. As an ornamental, however, it well deserves a place.

HACKBERRY.

A tree (*Celtis occidentalis,* L.) closely related to the elms, but of more upright habit and thrifty in poor soils. It is especially well suited to narrow and moderately wide streets and to the most trying conditions. Almost every mature tree exhibits curiously knotted branchlets called "witches broom," the result of disease. This, however, does no material harm. (See page 106.)

HORSE CHESTNUT.

A tree (*Aesculus hippocastanum,* L.) native to the Mediterranean countries, and often planted in the cities of Europe, yet not especially valuable there or here. Its fine form, beautiful leaves, which unfold very early, and great panicles of white flowers are its chief recommendations. It is also hardy in moderately good soil, and grows with fair

rapidity. Against these recommendations must be set its susceptibility to insect and fungus attack, the early fall of its leaves, the litter produced by its fruit and the liability to injury by reflected heat when planted on sunny streets. A tree of undoubted value for parkways and lawns, but it should be used with discrimination in other situations. One or two native horse chestnuts, or buckeyes, especially *A. glabra,* Wild and *A. octandra,* Marsh., are also sometimes planted.

LOCUST.

Common, black, or yellow locust (*Robinia pseudacacia,* L.) is so subject to injury by the borer worm (see page 83) that it should never be planted in this part of the country, either along the streets or on lawns. This is unfortunate because the light foliage and narrow form of the crown, with the hardiness and adaptability of the tree, make it an admirable one for street planting. Honey locust (*Gleditsia triacanthos,* L.), however, is less apt to be injured in this way. The tree is very hardy, not particular about the soil in which it stands, and a fairly rapid grower. Apart from the beauty of the foliage, which is unusually light and open, the flowers are full of honey and the stout thorns with which the trunk and branches are clothed make it particularly at-

Fig. 30. Trees left above grade. If others are planted at x, x, x, the old ones can be removed in a few years without injuring the property.

tractive. If these thorns are objectionable they can be removed or a thornless horticultural form may be used. The tree is somewhat late in unfolding its leaves, yet that is hardly a disadvantage. The long, coarse, pods that litter the pavements in the fall, or hang on the branches in winter, are more objectionable.

MAPLE.

No trees have been more widely used for street planting than the maples, yet in too many cases the wrong species has been employed, or the trees used in situations to which they are not suited. White, silver or soft maple (*Acer saccharinum,* L.) is planted everywhere, yet it is a poor tree, and for the reasons given on page 13 is not recommended. Norway maple (*A. platanoides,* L.) is altogether the best tree that we have for streets of moderate width. It is symmetrical in form, adaptable to almost any soil, hardy, and a fairly rapid grower. In autumn its foliage takes on the most brilliant coloring. The tree is little subject to serious diseases. Though several insects frequently attack it they usually do little harm. The drying of the leaves often noticed in early summer is usually due to deficient moisture, or to sunburn. It is to be prevented whenever possible, though it rarely does harm. (See page 116.) Red maple (*A. rubrum,* L.) is of somewhat more slender habit than Norway maple and thrives best in moist soil. It also is a good tree for streets of moderate width, though it sometimes suffers from sunburn. The younger branches are reddish and in autumn the coloring of the foliage is brilliant. Sugar maple (*A. saccharum,* Marsh.) is a larger tree than Norway maple, though in many respects so much like it that the two are often hard to distinguish. It thrives in cool situations, but invariably suffers when planted along paved streets. Except on wide streets with parking the Norway maple is always to be preferred. Ash-leaved maple, or box elder (*A. negundo,* L.) is a small tree whose only merit is that it accommodates itself to adverse conditions. It is short lived like silver maple, and is not recommended for the same reasons.

OAK.

It is decidedly unfortunate that the many oaks found in this country have not furnished more street trees. As a family they are undoubtedly the best shade trees that we have, for, with few exceptions, they are beautiful, long lived, and little subject to insects or disease. When properly planted and taken care of the growth of many of them is not slow. The following species are recommended. Red oak (*Quercus rubra,* L.), one of our grandest forest trees, is suitable for broad avenues. It is satisfied with comparatively poor soil, develops a straight, sturdy trunk surmounted by a broad symmetrical crown, not too dense, and its foliage turns a brilliant color in autumn. It is the most rapid growing of the oaks. Scarlet oak (*Q. coccinea,* Muench.) is much like red oak, but smaller in size, and does well on even poorer soil. Its leaves also are brilliantly colored in the fall, and quite persistent. Pin oak (*Q. palustris,* Muench.) grows taller and more slender than most other oaks and has an unusually straight stem. It is thoroughly at home on moist ground, but does not do well where it is dry. The leaves are less brilliantly colored than those of red and scarlet oaks and are apt to persist through the winter. Several fine avenues of this tree may be seen in Washington, D. C., and on Long Island. The white oaks, including bur oak, swamp white oak, chestnut oak and the English oak, are less valuable for street planting than for lawns. All are comparatively short but sturdy and with broad crowns. They are the longest lived of all our deciduous trees, and, contrary to the general impression, not at all slow growing when suitably located.

SYCAMORE.

A tree (*Platanus occidentalis,* L.) which normally, and under favorable conditions, grows to an enormous size, but is capable of being pruned and trained to meet the conditions imposed by streets of moderate width. It prefers a rich,

moist soil and in that grows very rapidly. Its peculiar habit of shedding its bark every year especially adapts it to locations in which there is much smoke. The leaves unfold late and are not brilliantly colored in the fall, but the globular fruit which persists through the winter, the free habit of the tree and its vigorous growth, recommend it highly. In some localities a fungus attacks the leaves just after they unfold, but the injury is not apt to be very serious or permanent. (See page 97.) Some planters prefer the European sycamore, or plane tree (*P. orientalis,* L.), yet its superiority is at least doubtful. It is said that one-third the trees planted in Paris are American sycamores.

TULIP POPLAR.

Liriodendron tulipifera, L., a magnificent tree suitable only for wide avenues with broad grass spaces, or for lawns. It absolutely requires good, well-drained soil; when that is given it grows with unusual rapidity and forms a tall, straight trunk with a comparatively narrow crown. Under other conditions it suffers from sunburn and many diseases.

Insects Injurious to Shade Trees.

By John B. Smith, Sc.D., *State Entomologist.* *

GENERAL CONSIDERATIONS.

In the following pages it is intended to refer to the leading species of insects infesting shade trees in the briefest possible manner only and to give, in the same way, directions for treatment. If further details are desired concerning the habits or characters of the insects referred to, they can be found in the Bulletins and Reports of the New Jersey Agricultural Experiment Stations, to which reference is also made for further information concerning insecticides and insecticide machinery.

Fuller information obtainable.

The colored plates exhibiting the more important insects were prepared by Mr. John A. Grossbeck, then an assistant in the author's laboratory. The drawings were made from published figures, credited as to source in Bulletin 181 of the New Jersey Agricultural Experiment Stations.

The order in which the insects are referred to here, is an indication of their relative importance.

THE ELM-LEAF BEETLE.

Pl. IV., Figs. 5, 5a, 5b.

The adult beetle lives through the winter, hiding in attics and other sheltered places. When the first elm leaves are full grown in spring it becomes active, begins eating irregular holes through the leaves and, in about a week, lays eggs. These hatch into yellow and black slugs which feed on the underside of the leaves, eating only the surface layer of cells, and cause them to turn brown, dry and drop. Early in July the larvæ crawl to the base of the

Attacks elms only.

*Died March 12th, 1912.

tree, change to yellow pupæ and by August 1st have changed to beetles. These feed for a few days and then go into hiding, to reappear the spring following. Attack elms only.

Remedial Measures.

Spray the infested trees with Paris green, 1 pound in 125 gallons of water, or, preferably, 1 pound of dry arsenate of lead in 25 gallons of water, as soon as the first beetle is seen feeding in spring, and soak the leaves thoroughly. The object is to kill the beetles before they can lay eggs, and therefore promptness and thoroughness are essential. (See page 88.)

If there has been delay and some eggs are already laid, it will be desirable to spray a second time as soon as larval feeding is observed, and this time every effort must be made to hit the leaves from the underside, because there is where the larvæ feed.

This will prevent serious injury.

If, nevertheless, any considerable number of slugs come to the ground to pupate, kill them off with boiling hot water or by sprinkling with kerosene. Cotton batting or sticky bands do no good.

THE WHITE-MARKED TUSSOCK MOTH.

Plate V., Figs. 2, 2a, 2b, 2c, 2d.

Winters on the trees in the egg-stage, in a little white mass on the cocoon of the female. Young caterpillars hatch in May and feed on almost all ordinary shade trees. Caterpillars when full grown have a bright red head, long pencils of black hair fore and aft, and stubby brushes of yellow hair on the back. General color yellow with a black stripe on back. Become full grown toward end of June and spin up anywhere on trees, on fences, under window ledges and other shelter on houses. In July the males emerge as dusty gray moths which flutter

Attacks various trees.

about in the early evening and seek the females which are wingless and rest on the cocoons out of which they emerged. The females lay egg-masses on these cocoons, cover them with a snow-white frothy secretion and die. Some of these eggs hatch and there is a partial second brood; abundant in South Jersey, scant in North Jersey.

Remedial Measures.

Clean off all egg-masses on trees during winter and band the trees in early May with fluffy cotton to prevent caterpillars from getting up from other trees. If the trees are infested spray with Paris green or arsenate of lead as prescribed for elm-leaf beetle. Arsenate of lead sticks better, never hurts foliage and, if well applied, needs only one application. The earlier it is used after infestation is noted the better results will be.

Band trees for this.

THE BAG-WORM, DROP-WORM OR BASKET-WORM.

Plate V., Figs. 3, 3a, 3b, 3c, 3d.

Winters in the egg-stage in a gray silken bag or sack, which may be found attached to trees and shrubs of almost all kinds, coniferous as well as deciduous. The eggs hatch in May and the young caterpillars at once make a little bag or sack which is enlarged as they grow and in which they live during their caterpillar life. Feed on the foliage, openly until July, then change to pupæ within their bags and in August the male moth emerges. This is black, very active, with transparent wings and is rarely seen. The female does not leave the bag but, after impregnation, lays her eggs in a mass of orange cottony material, then wriggles to the opening, drops to the ground and dies.

Attacks all kinds of trees.

EXPLANATION OF PLATE IV.

1, 3. The Cottony Maple Scale; *Pulvinaria innumerabilis.*

1a. *Pulvinaria acericola;* found only on leaves.

2. The Oyster-shell Scale, *Mytilaspis pomorum*, natural size.

2a. " " " female, enlarged.

2b. " " " male, enlarged.

3. Cottony Maple Scale, male, enlarged.

3a. " " " one of the recent sets, enlarged.

4. The Scurfy Scale, *Chionaspis furfurus*, natural size.

4a. " " " female, enlarged.

4b. " " " male, enlarged.

5. Elm leaf with Eggs and Larvæ of The Elm-leaf Beetle, *Galeruccella luteola*, natural size.

5a. Elm-leaf Beetle larva, enlarged.

5b. Adult Elm-leaf Beetle.

6. San José Scale, *Aspidiotus perniciosus*, enlarged. See Fig. 32.

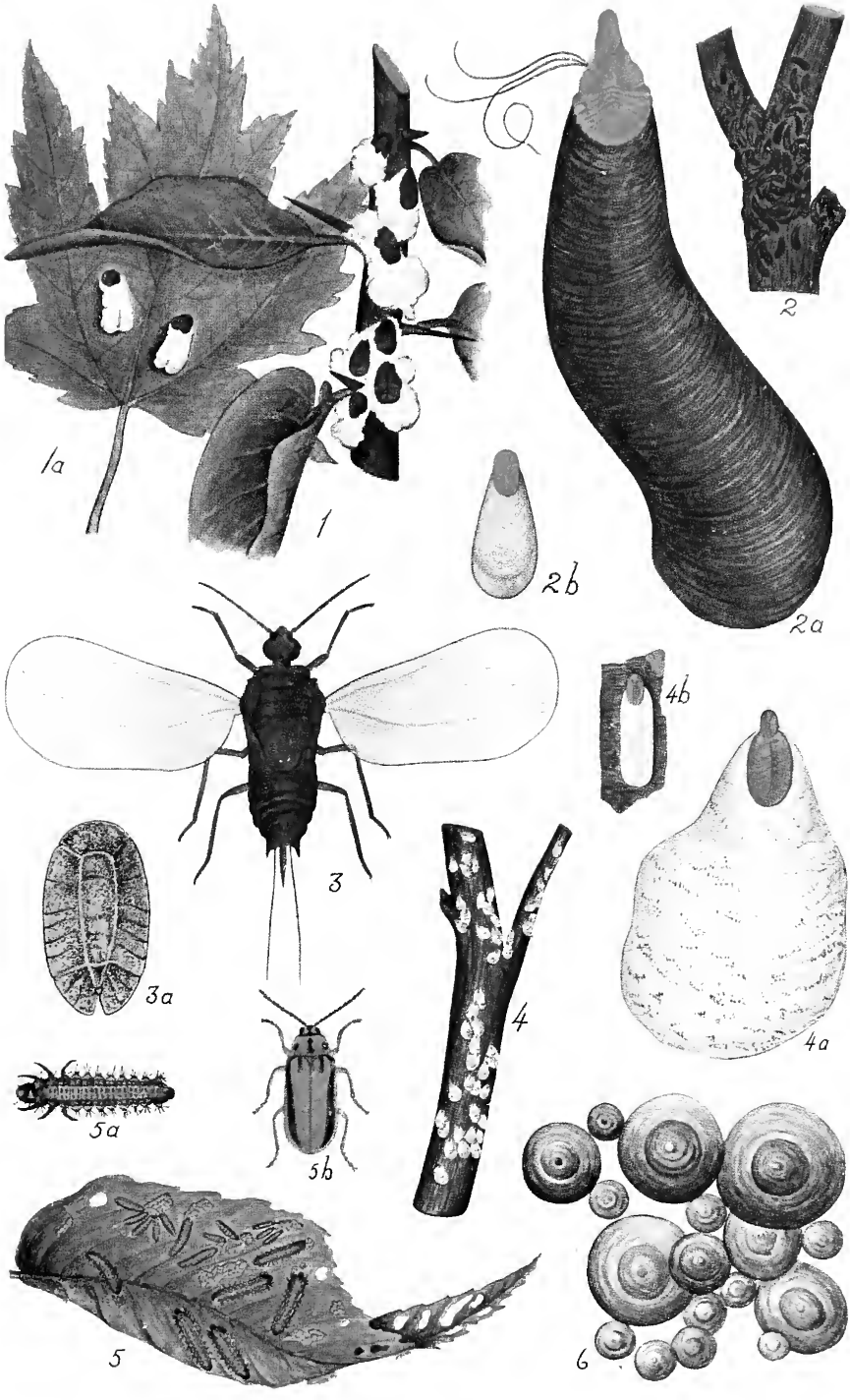

PLATE IV: See descriptions opposite

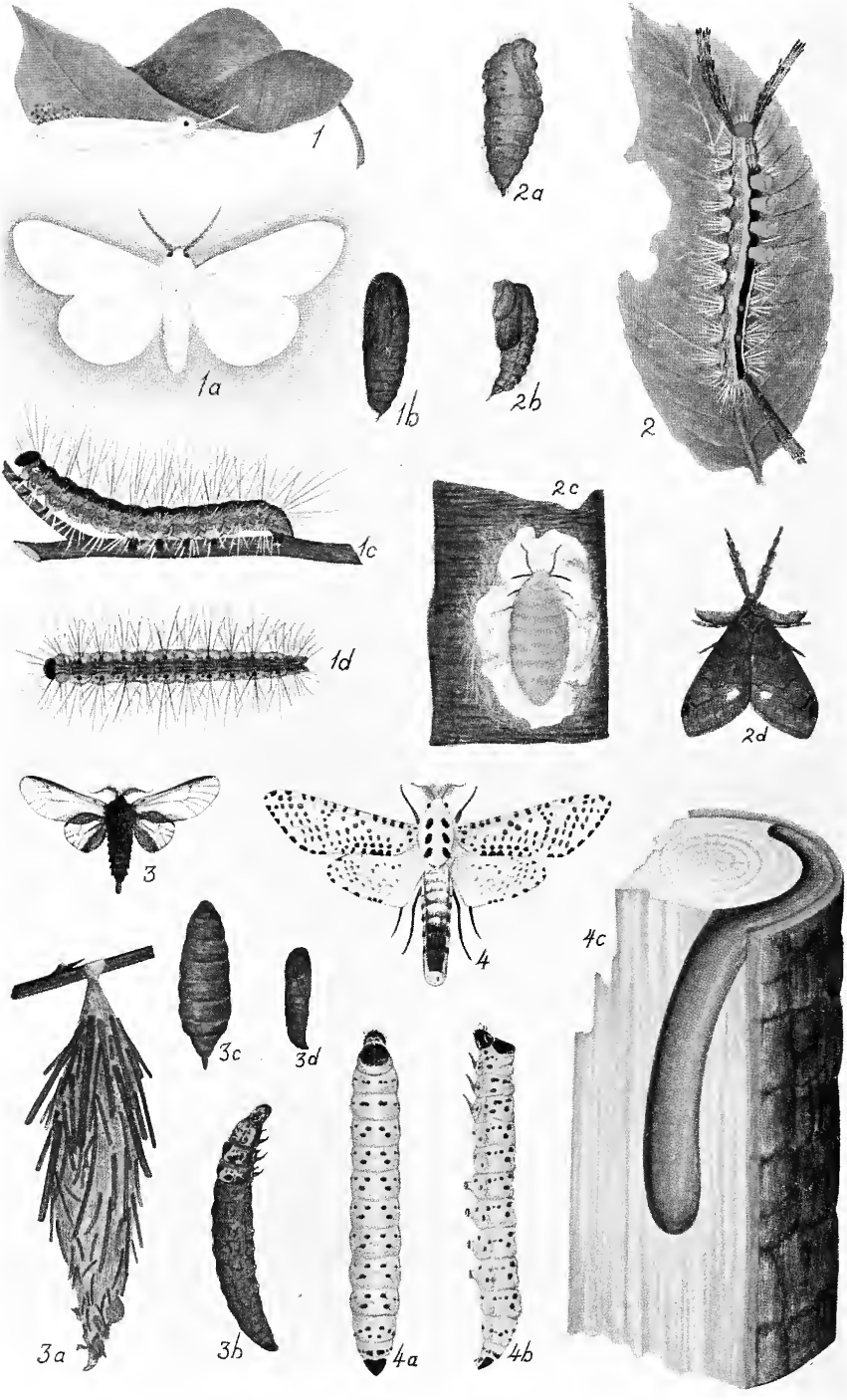

PLATE V: See descriptions opposite

EXPLANATION OF PLATE V.

1. The Fall Web-Worm; *Hyphantria cunea*—adult laying eggs.

1a. " " " adult moth expanded.

1b. " " " pupa.

1c. " " " larva.

1d. " " " varietal larva.

2. The White-marked Tussock Moth; *Notolophus leucostigma*, larva.

2a. " " " " female pupa.

2b. " " " " male pupa.

2c. " " " " female on egg mass.

2d. " " " " male moth, natural position.

3. The Bag-Worm; *Thyridopteryx ephemeræformis*, male adult.

3a. " " over-wintering bag which contains the eggs.

3b. " " larva.

3c. " " female pupa.

3d. " " male pupa.

4. The Wood Leopard Moth; *Zeuzera pyrina*, male.

4a. " " " " larva from above.

4b. " " " " larva from side.

4c. Work of the larva of the Wood Leopard Moth.

Remedial Measures.

On shrubs, and especially Arborvitæ and other evergreens, pick off the bags during the winter and burn them. On trees, where that is not feasible, spray thoroughly with arsenate of lead or Paris green as recommended for the elm-leaf beetle, just as soon as the young caterpillars are observed issuing from the bags. Conifers will not stand Paris green, but may be safely treated with arsenate of lead. There is only one brood of this species and winter work is especially recommended on hedge plants which are sometimes dense and not easily sprayed.

Pick off bags.

THE COTTONY MAPLE SCALE.

Plate IV., Figs. 1, 3, 3a.

Attacks Maples only, among shade trees; but found also on *Vitis, Ampelopsis* and other plants. The impregnated female winters as a brown scale on the twigs, resumes feeding in May, and late in that month or in early June begins to exude a white cottony mass in which a thousand eggs or more are laid. The minute young hatch in late June or early July, crawl about a few hours and then set on leaves, twigs and branches and suck the juices. When the insects are abundant, the leaves turn a sickly yellow, often become covered with honey dew, and badly infested branches may die. The insects mature in late August and September; the males issue as minute 2-winged flies, impregnate the female and die. The latter move from leaves to twigs and fix themselves firmly for the winter.

Attacks only maple trees, but other plants.

Remedial Measures.

This species is ordinarily kept in check by its natural enemies; but sometimes it escapes and becomes conspicuously abundant. It is always well, where easily accessible twigs are observed with forming white cottony masses in June, to cut them off and destroy them by fire, and this may in ordinary seasons be all that is necessary. If the infestation is very bad, cut off an infested twig in late June and lay it in a box on a sheet of white paper. When the paper becomes covered with rusty crawling dust-like particles the young are hatching, then spray the infested portions of the tree with whale-oil soap, 1 pound in 4 gallons of water, or with kerosene emulsion 1 part to 12 parts of water. (See also page 78.)

Ordinarily needs no control.

THE WOOD LEOPARD MOTH.

Plate V., Figs. 4, 4a, 4b, 4c.

This insect winters in the caterpillar stage in the wood of a great variety of deciduous shade and fruit trees, favoring maple and elm among the former. They live in the trees as borers for two full years, and in the spring of the third change to a pupa and then to an adult which is a large white moth with black spots, the males being strongly attracted to the electric light. The full-grown borer is two inches or more in length and often girdles branches of considerable size, or even the trunks of small trees. It is common only in the cities and towns in the east central part of the State from Paterson to Long Branch and west to New Brunswick, doing its greatest mischief in the largest cities where the English sparrows exclude the native birds.

Attacks many kinds of trees, but locally.

Remedial Measures.

On small trees the borers can be often found and cut out or destroyed with a soft wire run into their burrow, which opens outwardly, or bisulphide of carbon may be injected. (See page 83.) On larger trees gather and burn all the twigs and branches that fall to the ground or are blown down in high winds. Where dying branches are noticed, cut them off below the point of apparent injury and burn the cuttings. Inject bisulphide of carbon into all holes from which strings of sawdust are observed exuding, and plug up the opening with putty. When the moths are observed around the electric or other lights kill every one that comes within reach. Discourage sparrows and favor all other birds that come into town.

Kill one by one.

OYSTER-SHELL BARK-LOUSE.

Plate IV., Figs. 2, 2a, 2b.

This is the most common of the armored scales attacking shade trees, and derives its name from the resemblance to one of the very elongate type of oysters. It winters in the egg stage under the scale, and in May or June the eggs hatch into minute yellow crawling atoms that, in 24 hours, set and begin to form small scales. These suck the juices of the twigs and increase in size until midsummer or a little later. Then the males mature as small, two-winged flies, and the females, after impregnation, lay their yellowish white eggs which fill the space beneath the scale as the mother gradually shrivels up. South of the red shale line the tendency is to a second brood of these scales and in the sandy pine region the second brood is well defined. North of the red shale there is only one brood. Maples in South Jersey are often very seriously injured.

Attacks many trees and shrubs.

Remedial Measures.

There is only one period at which this insect can be satisfactorily reached; that is when the eggs have just hatched, and while the larvæ are moving about or have just set. The exact date cannot be given because it varies with the season and with the section of the State; but it will be during late May or early June. As soon as the larvæ are observed, spray with whale-oil soap at the rate of 1 pound in 5 gallons of water, or kerosene emulsion 1 part to 12 parts of water. Repeat if possible a week afterward, to reach delayed larvæ. This will usually prove effective, and will aid the natural enemies in getting control of the insects. Winter sprays are not useful against this species because the eggs are not affected beneath their scaly covering.

Spray at right time.

THE FALL WEB-WORM.

Plate V., Figs. 1, 1a, 1b, 1c, 1d.

This species winters in the pupal stage, and early in May the adult moth appears as a medium sized snow-white miller, sometimes more or less black dotted. It lays its eggs in a mass on the underside of a leaf, and the little caterpillars that hatch from them remain together, spinning a web in which they live and from which they emerge at night to feed. As they grow, the nest increases in size and may measure two or even three feet across, in large colonies. In July these caterpillars are mature, pupate and soon after produce a second crop of moths which in turn lay eggs from which caterpillars hatch in August, the nests becoming conspicuous late in that month or early in September. Because most people notice them only at that season they have received the name fall web-worm

Attacks most deciduous trees.

to distinguish them from the tent caterpillars in apple orchards which are most conspicuous in spring. Linden or basswood among the shade trees suffers most from this web-worm which, however, may be found on a great variety of deciduous trees.

Remedial Measures.

When a forming nest of these caterpillars is observed burn it with a long handled torch, cut it off and tramp it under foot or otherwise destroy it. When the nests are not accessible or have become so large that cutting would mutilate the tree, spray the foliage around the nests with Paris green or arsenate of lead as recommended for the elm-leaf beetle. It is not necessary to spray the entire tree, for the caterpillars do not move further from their nest than necessary to find food; hence spraying the vicinity of the nest is all that is needed.

Destroy nests.

THE MAPLE PSEUDOCOCCUS.

Late in the summer the trunks, and sometimes the branches, of sugar maples become covered with a white cottony or waxy substance, beneath which will be found yellowish, crawling, grub-like creatures. These sometimes increase so greatly in number that they form veritable layers, coating the trunks completely and extending to the leaves. When the latter are attacked they are apt to turn yellow and drop, so that in severe cases a tree becomes partly defoliated earlier in the season than is normal. The insect winters in the partly grown condition, hiding in the crevices of the bark, and not until after mid-summer does it usually become abundant enough to attract attention.

Attacks sugar maples only.

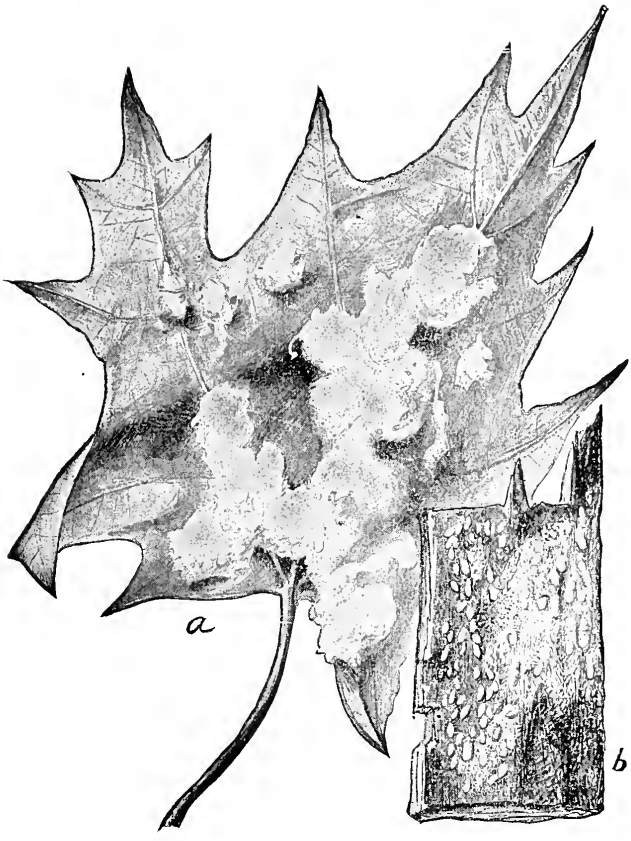

Fig. 31. The Maple Pseudococcus: *a*, the cottony masses covering the adult females on leaf; *b*, young of both sexes on bark
From Howard, U. S. Dept. Agl.

Remedial Measures.

When the infested leaves drop to the ground they should be regularly raked up and burnt. In the cities and towns where water pressure is available, a solid jet from a hose on the infested trunk will wash out and destroy the vast majority of the specimens, leaving not enough to do any harm. In winter the tree trunks may be sprayed with one of the miscible oils like "Scalecide," diluted with ten parts of water and applied with sufficient force

Wash with hose.

to penetrate into every crevice and irregularity of the bark. This will kill the hibernating forms and prevent any start next season.

Incidentally, the forcible solid jet just recommended, may be applied with a pump and small nozzle, and this has also been used to dislodge the cottony maple scales (see page 73) from twigs and branches early in the season before the eggs have hatched.

THE SCURFY SCALE.

Plate IV., Figs. 4, 4a, 4b.

This scale infests the poplar most frequently, among the shade trees, but is also found on maple and occasionally on others. It is very pale gray, almost as broad as long, with a yellowish point or head. Beneath this scale the purple eggs are found during the winter, and in June they hatch into purplish crawling larvæ which have the same general habits of other scale insects, and like them suck the plant juices. There is only a single brood which matures in September, and is rarely abundant enough to do any real injury.

Attacks poplar chiefly.

Remedial Measures.

This scale is thinner than most others of the armored forms, and may be reached by the lime-sulphur or other caustic sprays in winter. The caustic corrodes the scaly covering, and the eggs wash out and are scattered and destroyed on the ground. Even caustic lye or soda at the rate of 1 pound in 1 gallon of water will accomplish this. If no winter application is made it will be necessary to wait until the eggs hatch in June, and then apply whale-oil soap or kerosene emulsion as recommended for the oyster-shell scale.

If serious use caustic.

THE SAN JOSÉ SCALE.

Plate IV., Fig. 6; Fig. 32.

This is a small, round, blackish scale that passes the winter in the partly grown condition, comes to maturity in early June, bears living young and reproduces throughout the season so that a slight infestation in spring may mean serious danger before the year is over. Not many of the ordinary shade trees are subject to dangerous infestation when well grown; but young elms, especially of the European varieties, are sometimes much injured and occasionally killed.

Attacks fruit trees more than shade trees.

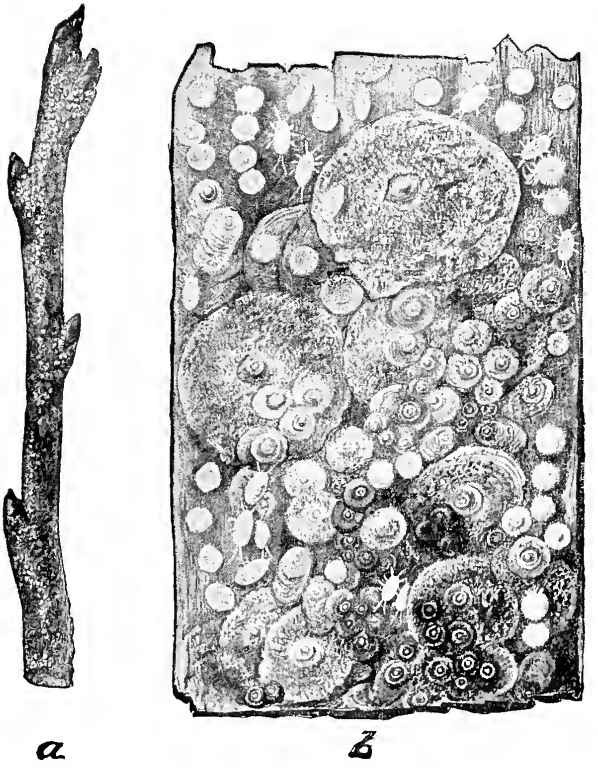

Fig. 32. The San José Scale: *a*, on a twig, natural size; *b*, as seen under a hand lens, much enlarged. Div. Ent., U. S. Dept Agl.

Remedial Measures.

As this insect bears its young alive, the period of reproduction is spread over a considerable period, and no one application can reach all, or even a large percentage, of the larvæ in the naked condition. In consequence, winter applications that are either very caustic or very penetrating are resorted to. The caustics are the lime and sulphur washes or whale-oil soap, the latter at the rate of two pounds in one gallon of water. The penetrating materials are petroleum oils, either undiluted or made miscible, or "soluble," in water. The latter are used at the rate of 1 part in 15 parts of water and the application must be very thorough to be satisfactorily effective. This is perhaps the most dangerous of all the scales and the hardest to control in the orchards. Fortunately none of our usual city trees seem to its liking, nor does it occur in our forests, although it is able to maintain itself on a number of our forest trees.

SPRAY.

THE TULIP SOFT SCALE.

This is a very large, livid gray scale, nearly ¼ of an inch in length, almost as wide and very convex. It occurs only on the tulip tree but sometimes infests that in great numbers and does more or less mischief, especially on young trees. It winters in the young stages on the twigs, often underneath old scales, begins growth in May and reaches maturity in August when the female is very offensive in odor and filled with a rank purplish material. In early September the small black young are born in great numbers and may set on the twigs so densely as to completely obscure the natural color of the bark.

Attacks tulip tree only.

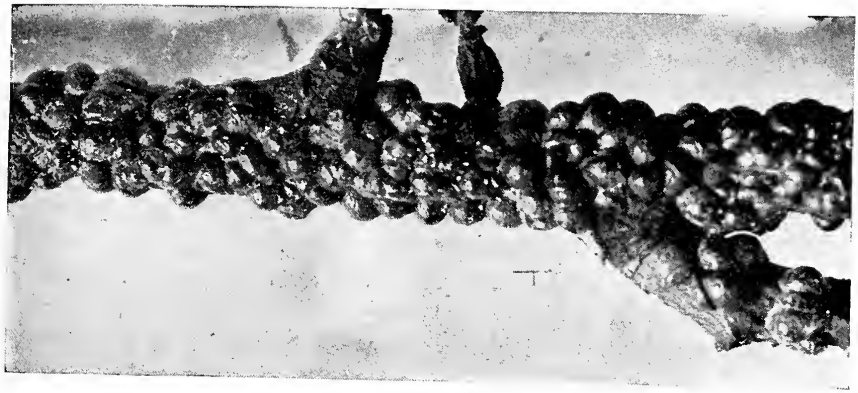

Fig. 33. A soft scale as it appears on badly-infested twigs.

Remedial Measures.

About the only really satisfactory application is undiluted crude petroleum as a winter spray. The miscible oils diluted no more than ten times, may answer the purpose; but have not been sufficiently tested. Whale-oil soap at the rate of 1 pound in 4 gallons of water applied just after they are hatched will kill the young, and this sort of application is feasible on small or moderate sized trees. On very large trees only the winter applications are at all practical. Fortunately this insect has some very effective natural checks which usually control it, so that except on young trees we need not often apply treatments.

Not often harmful.

OTHER SCALES.

There are a variety of other scales, mostly allies of those already mentioned, that at times infest shade trees, but rarely in sufficient numbers to require active treatment. As a rule winter treatments should be made if the species permits, for there is not at that season any interference of foliage and much stronger mixtures can be used on dormant trees.

BORERS.

A variety of borers infest shade trees and, as a rule, they attack, by preference, such as are weak and sickly. But that is by no means a universal rule. Maple trees are not infrequently infested by a small caterpillar borer that works into the heart-wood though it does little damage unless water finds entrance through their holes and causes decay. (See page 119.) The holes through which they emerge are not over 1/8 inch in diameter and nearly round. The moth is a pretty, clear-winged species, yellow, with bright red markings.

Usually attack weakened trees.

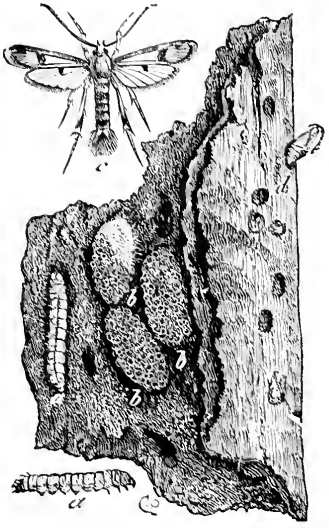

Fig. 34. The Maple Tree Sesiid: *a*, the larva; *b*, cocoons in cavities made by larvæ; *c*, the adult moth; *d*, pupa-shell projecting from trunk. After Riley.

As against this species frequent whitewashing the infested trunks and sealing up the holes with putty, is about the only thing that can be done, unless there is a decayed area acting as the centre of infestation. In that case the cavity should be thoroughly cleaned and treated as described on page 45.

In fact, the sort of treatment outlined in the above paragraph may be adopted against borers in general. Sometimes, when sawdust is noticed coming out of an opening, the injection of disulphide of carbon is indicated, plugging up with putty after the injection to prevent the escape of the fumes. Carbon disulphide may be injected with a syringe, or even the ordinary pipette with rubber bulb such as is used in filling fountain pens. I have a long glass tube drawn to a point, with a large rubber bulb at the squared end, which answers perfectly. It needs only a half teaspoon to a teaspoonful in any case.

Flat headed borers and bark beetles prefer trees that are weak or sickly and, in a general way, it pays to keep trees in vigorous health because of their smaller liability to borer infestation. When a tree is once badly infested, especially with bark beetles, the sooner it is cut out the better. It is simply a source of infection to its surroundings.

Hickory, and still more often Locust, is very subject to the attacks of round-headed borers, and these attack perfectly sound trees.

Locust Borer.

The work of this insect is very common on the black or yellow locust in New Jersey, making it an almost impossible tree. As soon as a tree attains a moderate size it is apt to be riddled with the large holes made by the larvæ and leads but a sickly life, if it does not die within a few years.

Attacks black locust only.

The beetles themselves are rather attractive creatures, about three-fourths of an inch long, of a dull black color, brightly marked with golden yellow, and may be found frequenting the flowers of the goldenrod. In September these beetles gather on the locust trees and mate, after which the female deposits her snow white eggs in cracks and crevices. These soon hatch and the grubs bore into the bark feeding on the soft inner substance. During the winter they are torpid. In spring they resume feeding, boring through the sapwood

and making irregular passages more or less deeply into the trunk. Honey locust is little, or not at all, subject to injury by this insect.

Remedial Measures.

Ordinarily it is impossible to do much to control this insect. Some persons have suggested a repellant wash to prevent egg deposition. It is certainly advisable to cut and burn badly infested trees during the winter. The beetle seems to like the sun and has a preference for trees somewhat exposed, therefore, thick shady groves would be least likely to be attacked.

No effective remedy.

HICKORY BARK BEETLE.

This beetle occurs throughout the State, boring under the bark of feeble or dying hickories, often killing shade trees that would otherwise have recovered under stimulating treatment. The beetles, which are small, brown or black, about one-fifth of an inch long, appear from the latter part of June to the latter part of July. Attacking the bark of the trunk and large branches, each female makes a vertical gallery an inch or more in length. Notches are cut in the sides of this burrow, for the purpose of holding the eggs. After hatching, the grubs construct channels diverging from the main gallery. (See Fig. 35.) The winter is passed by the nearly full grown grubs, which pupate the following spring.

Dangerous only to weak trees.

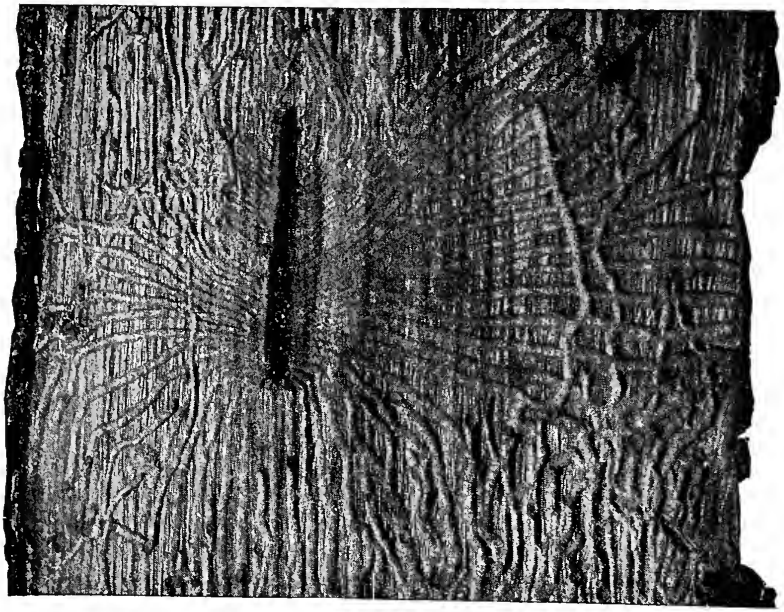

Fig. 35. Work of the hickory bark beetle.

Remedial Measures.

Where a slight infestation is noticed on a tolerably healthy tree, the tree should be stimulated by means of appropriate fertilizers (see page 25), and the trunk kept covered by whitewash to which Paris green has been added. Strong whale-oil soap suds will answer the same purpose. If a tree is seriously infested, it should be cut down at once and burned, as it is certain to die in a short time anyhow and is only a menace to surrounding trees.

Stimulate good trees.

PLANT LICE.

Most of our shade trees suffer from plant lice to a greater or less extent, and none more than the Norway maples. These insects multiply very rapidly, suck the juices of the

leaves and succulent shoots, and so exhaust their vitality.

Maple louse.

When they become abundant the honey dew excreted by them sometimes covers the leaves with a sticky secretion that may be abundant enough to drop to the street below. This secretion tends to clog the foliage so that it may drop while yet perfectly green, and a black soot fungus is also likely to develop. Fortunately this sort of attack does not continue after the first spell of hot dry weather, and during a normal season is not apt to be bad at all.

Remedial Measures.

As against plant lice of all kinds on shade trees, nothing is much better than whale-oil soap suds and this applies not

Whale-oil soap.

only to those species that attack the leaves but to some that gather along the undersides of branches of conifers. In general, 1 pound in 4 gallons of water is an effective strength, and safe on most kinds of foliage.

INSECTS INJURING CONIFERS.

Pines and other conifers are not often used as street trees, but are not infrequently found in parks and grounds around residences. They suffer from a variety of insects and are not easily treated, because they are extremely sensitive to most insecticides. Against feeders upon the leaves, arsenate

Lice.

of lead is the only arsenical poison that can be safely used. When plant lice attack them, whale-oil soap suds, one pound in six gallons of water, liberally applied, will be safe and reasonably effective. Against those woolly species that are frequently found massed against the underside of the branches, a forcible jet of water is often very satisfactory or the whale-oil soap may be used, 1 pound in 4 gallons of water, locally applied. If the trees are sufficiently valuable, simply scrub the branches with a stiff brush and weak soap suds.

Scales sometimes infest the needles; but on large trees are never harmful in my experience. On small trees watch for the hatching of the eggs in June and use the whale-oil soap, 1 pound in 6 gallons, liberally.

Scales rarely harmful.

White pines are sometimes deformed by the attacks of the white-pine weevil which lays its eggs in the leaders, the larvæ boring into and killing them. It is the young trees that are usually affected and in most instances the form of the tree is permanently spoilt. Fortunately the insect is not at all common in New Jersey, and young trees if kept under observation may be protected by collecting the adults or, what is more practical, keeping the leaders sprayed during May and June with whale-oil soap suds one pound in six gallons of water, adding half a pound of arsenate of lead to this mixture.

White-pine weevil.

If the leaders are at any time observed to be lacking in vigor or to be unnaturally yellow in color, they should be carefully examined, and if any signs of feeding are noticed every puncture should be followed with a soft wire to reach the feeding larvæ. If this is done in time the shoot will recover. If the feeding is already well advanced so that recovery seems doubtful cut and destroy by fire.

GENERAL CONSIDERATIONS.

Shade trees in general should be kept free from dead or dying wood, and all cut wood should be destroyed by fire. It is always in order to clean the bark during the winter by means of soda or lye washes which get rid of the growth in or under which many insects hibernate. A strong soap solution, even of ordinary laundry soap, will often do a great deal of good, and it can be used to advantage on the waxy plant lice or mealy scale bugs during the winter.

Keep trees healthy.

When there is an application of an arsenical spray to be made, the sooner it is done the better the effect; young or

partly grown specimens succumbing more rapidly and easily than more nearly mature forms. A single defoliation rarely harms a deciduous tree very much; but successive defoliations weaken and eventually kill. And always a healthy, well fed tree is less attacked by insects than a sickly starved example which gives up in despair at the least provocation and invites attack by its very inability to resist.

SPRAYING.

Municipal work.

Among the first things that must be realized in planning work to avoid insect injury to city trees, is that by no means all kinds of trees are equally subject to such injury, nor is there any one treatment that is equally effective against all insects. There may be one city with 1,000 trees on which insect injury may be kept down by a single man during the season; another with half that number may require a power sprayer and a gang to run it for a month.

Get a good machine.

At the beginning, find out what trees there are and their condition. Then, with the assistance of the entomologist, you are in position to determine what outfit is needed to carry on the work. It is quite possible to get a cheap sprayer, which is, at first, adequate when run to the limit; but no piece of machinery does well for any considerable period when run to the limit, and a cheap outfit is usually a small one. You can get a barrel with a pump that will force a spray to the top of even a large elm, and I have personally worked with such an outfit; but it was hard on the man at the pump, the tendency was to lose pressure and too much time was lost in the frequent tank fillings required.

For municipalities with trees running into the thousands, power sprayers are essential, but no municipality that needs a sprayer at all, should get anything less than a 200-gallon tank upon which a pump capable of furnishing 100 pounds of pressure to two lines of hose should be mounted. The

pump need not be of large capacity, for it is not expected to throw large quantities of water in a short time; but it should have a large air chamber and should be capable of supplying a maximum amount of pressure with a minimum amount of work. The stroke need not be long, but the lever should be long and strong, and the pump should be horizontal, not vertical. An up and down stroke is tiresome and cannot be long maintained without losing in strength; a horizontal stroke may be aided by the weight of the body, and both or either hand and arm may be used. All these matters are important, because upon the amount and uniformity of the pressure the thoroughness of the work depends in large measure. The working parts of the pump should be of brass, the valves and packing should be of metal and the valve seats should be readily accessible. Such a piece of machinery will stand every reasonable strain that is likely to be put upon it, and will come out at the end of the season almost as good as it was at the beginning. It will never be worked to its limit in tree spraying, and with reasonable care will last many years without much expense. Such a pump is never cheap at first cost, but is a cheap pump in the long run. Of course no piece of apparatus is entirely fool proof, and that fact should be kept in mind when hiring men to work it.

The pump.

There should be two lines of ¾ hose, best quality, each 100 feet in length, and there should be 6 or 8 foot gas pipe spray rods, at the ends of which the nozzles should be fixed. There should be a shut-off at the base of each spray-rod and one rod should have a solid jet nozzle for reaching the tops of trees, while the other should have an adjustable or bordeaux nozzle for making a spray to reach the lower branches.

As to the poison to be used, there is nothing better than arsenate of lead for all leaf-feeding insects, and for choice I prefer the dry, powdered form because of its greater convenience in handling and because of its keeping qualities. If the paste form is used, it should be purchased on guarantee of percentage of arsenic, for it runs all the way from 12 per cent. to 20 per cent., and may

Arsenate of lead.

be a pure material in each instance. Anything that runs 15 per cent. or over is good, and nearly all the leading brands sold in the State reach that percentage. The dry material runs 30 per cent., and is therefore about twice as strong as the average paste. None of the leading brands have more than a trace of soluble arsenic, and practically it is impossible to injure the foliage of any shade tree with any mixture likely to be put on by even an ignorant laborer.

All the commercial tank sprayers have an agitator which keeps the spraying mixture stirred while pumping, and something of that sort is needed in any case, so as to make sure that the material is uniform throughout the spraying period.

In all cases the poison should be first mixed up with water in a pail or tub so as to get it into a smooth thin paste. This should be gradually run into the tank while filling, and the agitator should be kept constantly going, so as to get a thoroughly even poisonous mixture to start with. Then, while a slow settling does begin almost immediately, it is very slow and the mixture can be kept in proper shape with very little stirring. It is always better to use up a tank full of mixture completely, as soon as possible after it is made, and it should never be allowed to stand over night. It never stirs up quite as completely next day, and if part of a tank remains unused at the end of a day's work, better take out the plug and let it run to waste than try to save it for a future day.

Stir the mixture.

With a proper outfit and a good crew, the next point is to get the material on in such a way as to be most effective. An ideally effective application would be one in which every leaf received an even and complete coating of the spray, so that not a particle of the foliage could be eaten by any insect without its receiving at the same time a dose of poison. As we cannot hope for ideally effective work, we must try and get as close to it as possible, remembering always that no one insect eats very much, and that every female specimen that gets a safe meal may lay a batch or two of eggs before getting another, and perhaps fatal, bite.

Coat leaves thoroughly.

The lesson of thoroughness cannot be too strongly inculcated, and it is better to be wasteful of time and material to secure this, than to do much in an unsatisfactory way. Every missed branch will stand out later, and to avoid this the crew should be taught to work in some systematic manner, so as to reach all parts of a tree.

Concerning the cost of machinery and operation, no one set of figures will cover all conditions. A barrel pump outfit complete, with a short line of hose, rod and nozzle can be had for as low as fifteen or twenty dollars, while a power sprayer consisting of an engine, pump, 200-gallon tank and truck may cost from three hundred dollars up. **Cost.**

As for the cost of operating, this depends on the size of your apparatus, number of men necessary to operate it, number of trees and their accessibility, availability of water and in fact numerous other conditions, which will not become apparent until the work is under way. Where conditions are favorable large trees are often well sprayed for as little as one dollar each. Whatever the cost, if one succeeds in checking insect ravages, he will be amply repaid by the increased vigor and beauty of the trees.

Diseases of Shade and Forest Trees.

By Mel. T. Cook, *State Plant Pathologist.*

The increasing appreciation of the great commercial value of our native forests, and of the importance of trees for shade and ornamental purposes, has stimulated the study of methods for the proper care of trees. This conservation movement has been emphasized by the ravages of the chestnut blight, or bark disease, and our growing knowledge of other threatening diseases. The fact that it is possible to prevent the loss of many fine trees, which it has required years to grow, makes it very desirable that we should give careful attention to this subject.

Trees, in fact all other plants, are subject to diseases which are due to more or less well known causes and are as well defined as the diseases which attack animals. Like the diseases of animals, the diseases of plants may cause loss of color, loss of parts, deformities and, in some cases, death. The diseases of both animals and plants are caused by fungi, bacteria, insects, worms, unfavorable surroundings, etc. Among animals the most common causes of disease are bacteria, while among plants the fungi are responsible for by far the greater number.

Causes of disease.

A fungus is a plant which does not possess the green coloring matter, chlorophyll, and therefore cannot draw its nourishment from the air, soil and water, but must live upon other plants and animals, living or dead. Those which live upon and draw their nourishment from living organisms are known as parasites and are the causes of many diseases; those that live upon dead matter are known as saprophytes. The fungus may be so small as to require the use of the microscope in order to see it, or it may be a minute thread-like structure

Parasites and saprophytes.

which grows over the surface of, or penetrates, its host, eventually coming to the surface to produce its fruiting bodies or sporophores. These sporophores may vary in size from the microscopic in some species to the very large structures of other species which are usually known as mushrooms or toadstools. These familiar fruiting bodies on trees may be from parasitic fungi which *cause* diseases, or they may be from saprophytic fungi which *follow* diseases and live on the dead and decaying material. In order to definitely determine this point it is necessary for the observer to be familiar with the organisms.

Not all fungi dangerous.

Some of these fungus diseases are very destructive to forest, shade and ornamental trees, and every effort should be made to eradicate or control them, but most of them are of minor importance. The majority of the large fungus growths are saprophytic, and although not the cause of diseases they destroy great quantities of timber which would otherwise be useful. In this paper only the more common and conspicuous diseases will be discussed, but some others which at the present time are of minor importance in the State will be mentioned.

Classification of diseases.

Any part of the plant, roots, stems, leaves, flowers and fruits, are subject to the attack of diseases, but the disease is not always manifest at the point of attack, *i. e.*, a disease of the roots may frequently be detected by a dying of the leaves and branches. For convenience the diseases of trees may be arbitrarily grouped as follows:

1. Diseases of the foliage.

2. Diseases of the stems.

3. Diseases of the roots.

4. Diseases due to environment.

5. Other diseases.

1. DISEASES OF THE FOLIAGE.

The foliage contains the greater amount of the green coloring matter, or chlorophyll, by which a plant is enabled to utilize the raw food materials which it receives from the air and soil. Therefore any great reduction of the foliage surface during the growing season results in a proportional reduction in the working power of the plant and also mars its beauty for ornamental purposes.

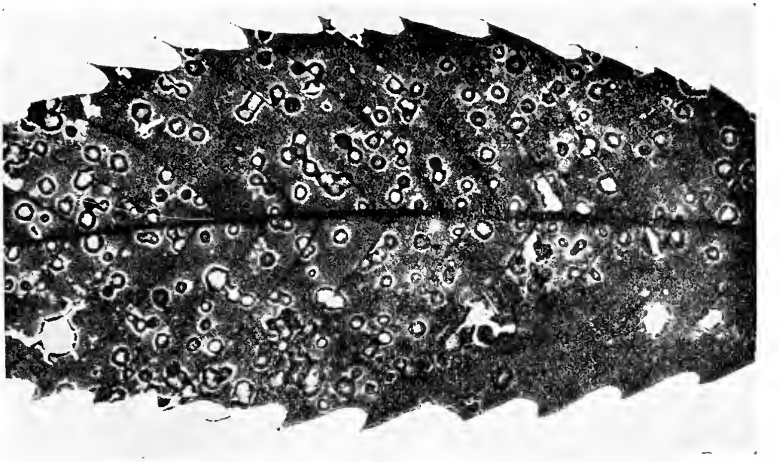

Fig. 36. Chestnut Leaf Spot. (From Report of N. J. Experiment Station, 1896, Fig. 59.)

Leaf Spots.

These diseases are caused by a number of parasitic organisms, principally fungi and bacteria, which cause discolored areas on the foliage, frequently followed by a breaking out of the dead tissues, thus leaving unsightly holes. The character and severity of these various leaf spots vary with the organisms to which they are due and also with climatic conditions. Among the most important of these leaf-spot fungi on shade trees are the following:

WALNUT. *Marsonia juglandis* Lib. causes a brown spot on the black walnut and butternut, gradually increasing in size and frequently covering the entire leaflet.

CHESTNUT. *Marsonia ochroleuca* B. and C. causes numerous circular, ashy white spots on the chestnut. (Fig. 36.) The dead tissue of these spots breaks leaving holes and the entire leaf finally turns brown and falls prematurely.

ELM. *Dothidea ulmi* Duv. attacks elms causing conspicuous black spots. Frequently the foliage is badly infected and the beauty of the tree seriously marred.

MAPLES. *Rhytisma acerium* Pers. attacks many of the maples, but is most severe on the silver maple, causing shiny, black, hard, slightly elevated patches commonly known as tar spots. (See below.)

HORSE CHESTNUT. *Phyllosticta paviæ* Desm. is the cause of an important leaf spot or blotch. The spots are irregular in shape, increase rapidly in size until the greater part of the leaf is brown and has the appearance of being sun-burned. The leaves fall early and the vitality of the tree is reduced. This fungus is frequently accompanied by others which aid in its injurious work.

CATALPA. *P. catalpæ* Ell. and Mart. and *Cercospora catalpæ* Wint. are the causes of unsightly leaf spots on the catalpa. They are frequently accompanied by *Macrosporium catalpæ* E. and M. and *Microsphæra elevata* Burr.

MAPLE. *P. acericola* C. and E. is the cause of a leaf spot of the maple, which is frequently so severe as to cause a premature dropping of the foliage. (See above.)

Treatment.

The burning of the fallen leaves, thus destroying enormous numbers of spores which could otherwise be distributed by wind and water, will greatly reduce these diseases. Where practical to do so, spraying with Bordeaux mixture will hold them in check.

Anthracnoses.

These diseases are very common and attack many different species of plants. They are due to fungi and many of them are also found on stems and fruits. On the foliage they may cause spots or holes, or a withering very similar to that caused by frost.

Sycamore.

The most important of the anthracnoses on shade and ornamental trees is that on the *Sycamore*, caused by the fungus *Gnomonia veneta* * (Sacc. and Speg.) Kleb. In the earlier stages of the disease it follows the veins of the leaves, from which it eventually spreads. It also attacks the young shoots. In severe cases the leaves are entirely browned and withered and have very much the appearance of those injured by frost, for which the disease is frequently mistaken. It often kills the young shoots and sometimes kills the seedlings and young trees. This fungus is also said to cause leaf spots on several species of oak.

Treatment.

Dead branches should be pruned out and the rough, loose bark which may retain the disease should be removed and burned. The trees should also be sprayed with copper sulphate or lime-sulphur during the resting period, then with Bordeaux mixture soon after opening of the buds, again in ten days and again ten days later.

Powdery Mildews.

The powdery mildews are due to fungi and are well known on many plants. These fungi, unlike the preceding, do not

*One stage of this fungus has been described under the name *Glocosporium nervisequum* Fckl. by which it was long known and by which is was referred to in the Fourth Annual Report of the Forest Park Reservation Commission of New Jersey 1908.

penetrate the foliage, except so far as may be necessary for the formation of holdfasts, but spread over the surface of the foliage forming a delicate white web which has much the appearance of dust.

Symptoms.

One of the most important of these mildews is *Microsphæra alni* (Wallr.) Wint. which attacks lilacs and also occurs on the oaks, birches, dogwoods and some other plants. Another very common mildew is *Uncinula salicis* (D. C.) Wint. which occurs on the poplars and willows. As a rule, they do not appear until late in the season and cause very little injury except to young trees and nursery stock.

Treatment.

Spraying with potassium sulphide (1 lb. to 50 gal. of water) is an efficient remedy.

LEAF CURL.

The leaf curls are more or less common on many trees, the most conspicuous being the one on the peach. The most important one on forest and shade trees is due to *Taphrina cærulescens* (Mont. and Desm.) Tul. which attacks the oaks causing the leaves to appear as though blistered. It is not often injurious but sometimes causes death of trees which have been affected for a number of years.

Attacks oaks.

Treatment.

The burning of fallen leaves and spraying the trees with copper sulphate or lime-sulphur when dormant will practically eliminate the pest.

Rusts.

The rusts are among the most highly developed of the parasitic fungi and attack foliage and fruit. Some of them are very destructive while others are comparatively insignificant. Many of them have very complicated life histories and require two host plants to complete their life cycle and in many cases to perpetuate themselves.

Importance.

One of the most conspicuous of the rusts is the *Gymnosporangium macropus* * Lk., which attacks the red cedar and the apple. On the red cedar they cause the formation of the large reddish brown bodies known as "cedar apples." During the period of early spring rains the mature cedar apples produce long yellowish or orange colored horns within which are produced great masses of fungus spores. These spores will not attack the cedar but are carried to neighboring apple trees where they attack the leaves, and sometimes the young twigs and fruit, causing yellowish or reddish orange spots. On the under side of each spot are produced a number of small cup-like cavities within which are borne the spores. These spores are in turn carried to the cedars where they attack the young shoots and eventually cause the formation of the next year's crop of "cedar apples."

Cedar apples.

Treatment.

This fungus may be held in check by removing the cedar apples early in the spring before the maturing of the orange colored horns, and by the proper spraying of the apple orchards.

Among other interesting diseases of this kind are the rust, or leaf cast, of the Jersey or scrub pine, the rust of the Scotch and pitch pines which has an alternating stage on the sweet fern, the leaf rust of the hemlock, rusts of the willows, poplars and ashes.

Other plants affected by rusts.

*There are several species of *Gymnosporangium* attacking cedars and with various species of the Pomaceæ as their alternating hosts.

None of these rusts are considered serious and treatments are seldom given. The blister rust of the white pine, however, which attacks the stems is most dangerous and demands most vigorous treatment. (See page 103.)

2. DISEASES OF THE STEMS.

The diseases of the stems may be arbitrarily grouped into (a) bark diseases, (b) heart rots, (c) sap rots, and (d) twig diseases.

Fig. 37. Chestnut Bark Disease. Forest tree nearly dead. Note characteristic sprouts and dwarfed leaves on surviving branches. (Photo by Perley Spaulding.)

Chestnut Bark Disease or Blight.

This is probably the most serious tree disease in America at the present time. It is caused by a fungus (*Diaporthe parasitica* * Murrill) which lives parasitically in the bark, sending its minute thread-like processes in all directions from the point of attack until the trunk or branch is completely girdled. (Figs. 37, 38.)

It is very doubtful if the fungus can gain entrance to a tree except through wounds, and it is probably carried from

Fig. 38. Section of Chestnut tree killed by blight with bark in successive stages of decay and pustules in which the winter spores are borne. (Photo by J. F. Collins.)

place to place by boring insects and by birds (especially woodpeckers). It is also carried on infected timber shipped into

*The proper name of this fungus is at the present time a disputed point which will require further study before it can be definitely settled.

uninfected territory. Many new points of infection have been traced to diseased nursery stock. Nurserymen should use every caution to prevent the spread of the disease by keeping a careful oversight of their stock. Unfortunately, the disease cannot always be detected at the time of shipment, and therefore young trees should be kept under careful supervision by the grower. It is unwise at this time to plant chestnut in this State, and growers in territory beyond the present range of the disease should be absolutely sure of the healthy character of the stock used for planting. The spread of the disease has been so rapid, the destruction of our chestnut growth so great, and the financial losses so heavy, that it has attracted more attention than any other plant disease in recent years. Large sums of money are being expended in fighting it, but up to the present time no satisfactory method has been devised. The planting of chestnuts in the infected districts is a waste of both time and money.

Spread of the disease.

Treatment.

Individual trees and small plantings may be protected to some extent by frequently cutting out the diseased parts and painting the wounds with coal tar. In doing this all the prunings must be burned. When forest areas become affected their final destruction is practically certain, and the owners are advised to convert the entire chestnut growth into salable material as rapidly as possible. Otherwise it will prove a complete loss. Material too small for lumber should have the bark removed. All waste material should be burned at once.

The severity of this disease, the rapidity of its spread, and the desire of the people to protect their trees have developed a most fertile field for the quack tree-doctors who are claiming to cure trees by secret methods. These methods usually consist in putting secret preparations under the bark or in the soil about the roots of the trees. Similar methods have been used for other tree

Tree fakirs.

diseases in various parts of the country, but without success. There are no such treatments for diseases of this character known to science, and the authors of these secret methods freely acknowledge that their treatments are not recognized by scientific workers. The public is cautioned against patronizing these people.

White Pine Blister Rust.

The blister rust (*Peridermium strobi* Klebahn*) of the white pine, a European disease which has been introduced into this country and apparently stamped out, but which may be introduced again at any time, causes a spindle shaped, or sometimes irregular warty swelling on the trunks of seedlings and young trees and upon the young branches of older trees. (Fig. 39.) Those swellings do not occur until one or more years after the infection, which makes it impossible to detect the disease in its earliest stages. As these swellings approach maturity they form on the surface rounded or elongated bodies measuring one-eighth to one-half inch across. The bodies have delicate, whitish membrane coverings beneath which may be seen masses of orange-colored spores. This membrane ruptures, allowing the spores to escape (April to June), but may persist for some time after the spores have been carried away. If the spores are carried to gooseberries or currants they attack the foliage and young shoots and cause the "velvet rust" which produces two kinds of spores, one kind by which the fungus can spread on the gooseberries and currants and another by which it is returned to the white pines. The disease is of very little importance on the gooseberries and currants, but is very destructive on the white and other of the *five-leaved* pines. It attacks none of those with two or three needles.

Symptoms.

Alternating hosts.

**Peridermium strobi* Klebahn of the white and other five-leaved pines is the same as *Cronartium ribicola* Dict. of the currant and gooseberry.

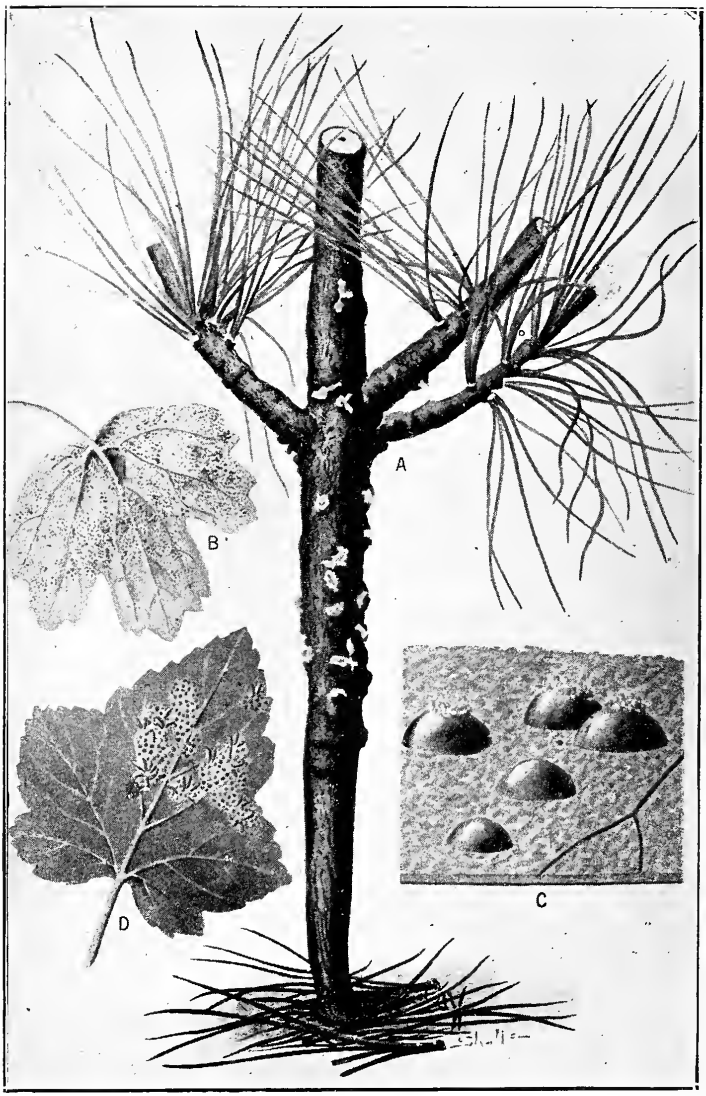

Fig. 39. White Pine Blister Rust. A. A four-year-old tree with the disease; B. Leaf of *Ribes aureum* showing uredospore stage; C. Portion of same enlarged; D. Leaf of *Ribes americanum* showing teleutospore stage. (From Bul. 206, Bureau of Plant Industry, U. S. Dept. Agricul.)

Within the past few years the demand for white pines for reforestation and for ornamental plantings has been so great that large numbers of the seedlings have been imported from Europe. The disease has been introduced on these seedlings and distributed to many localities in the United States, but fortunately has been kept in subjection. The disease is very destructive to seedlings and young trees and, while not always destructive, is very injurious on the older trees. Therefore we should use the greatest caution to prevent its getting a foothold in this country.

Destructiveness.

Treatment.

It is not advisable to plant five-leaved pines of European origin. *Always use American grown seedlings.* Even then the plants should be carefully examined from time to time, and in case the disease appears they should be destroyed immediately by burning. There is no known remedy for the disease, and absolutely no safe course to pursue other than burning the diseased plants.

Coral Spots.

The coral spots on the bark of trees and shrubs are due to fungi belonging to the genus Nectria. They are readily recognized by the small brightly colored red or orange fruiting bodies. There are a number of species, but the most important is *N. cinnabarinna* (Tode) Fr. which attacks the maple, horse-chestnut and many other deciduous trees. The fungus gains entrance to its host through wounds, gradually spreads, forming well defined cankers within which will be found the highly colored fruiting bodies. When once well established it may spread rapidly from plant to plant and become epidemic. This fungus also attacks currant bushes and pear trees.

Symptoms.

Treatment.

The only practical method of control consists in cutting and burning diseased parts.

BLACK KNOTS.

These unsightly growths occur on the twigs and leaves of some trees. Among the most important are those on the plums and cherries which are caused by the fungus (*Plowrightia morbosa* Sacc.), and those upon the hazel caused by the fungus (*Cryptosporella anomala* Pk.).

Treatment.

They are of no very great importance on shade trees, but can be controlled by cutting out and burning early in the fall and by spraying with copper sulphate or lime-sulphur before the buds open in the spring.

WITCHES' BROOMS.

These conspicuous and unsightly growths are quite common and are due to the attacks of both fungi and insects which cause the formation of masses of short twigs and are sometimes mistaken for mistletoe growths. (See page 107.) The most common and most conspicuous is the one on the hackberry. (*Celtis occidentalis* L.) This is so common that it is extremely difficult to find a tree that does not have them, and many people consider them a characteristic growth of the hackberry. However, they are a disease, and if the tree is kept free from them, it makes a very beautiful growth. The disease is said to be due to two parasitic organisms, a powdery mildew (*Spærotheca phytoptophila* Kell and S. W.) and a mite (*Eriophyes sp.*)

Some of the species of the cedar rust (*Gymnosporangium*) (see page 99) and the leaf curl fungi (see page 98) are also the cause of witches' brooms which die and are broken out by the wind storms, thus leaving irregular and unsightly trees.

Treatment.

As witches' broom is more unsightly than harmful, it may be ignored or the trees may be pruned as for other defects.

Mistletoes.

Mistletoes are true flowering plants which live parasitically upon many of our native trees. The common American mistletoe (*Phoradendron flavescens* (Pursh) Nutt. is rare in New Jersey, occurring mostly on the black gum and red maple. Where very abundant they are considered serious enemies. It will be readily recognized that parasites of this kind will naturally retard and stunt the growth of the tree. They are also the cause of unsightly swellings and some of them cause witches' brooms. Their life is usually shorter than that of the trees on which they live, and when they die and decay they leave cavities which are especially favorable for the introduction of pathogenic fungi and other organisms of disease. Mistletoes are so rare in this State that most people will be inclined to look upon them as objects of interest rather than as serious pests.

How harm is done.

Treatment.

They can be controlled by pruning out the diseased parts and painting the wounds with white lead or coal tar.

HEART ROTS.

Heart rots are extremely destructive to both living and dead trees. They are due to a number of fungi, many of which are both parasitic and saprophytic. The fact that many of these organisms will live on the dead wood from which they readily pass to the living trees makes it very important that all such dead and decaying material be removed and burned.

WHITE HEART ROT.

This is a true disease caused by the false tinder fungus, *Fomes igniarius* (L.) Gillet. It attacks the beech, aspen, willows, maples, birches, walnuts, oaks, hickory, apple, etc. The organism gains entrance through wounds and grows in the heart wood which it trans-

Trees attacked.

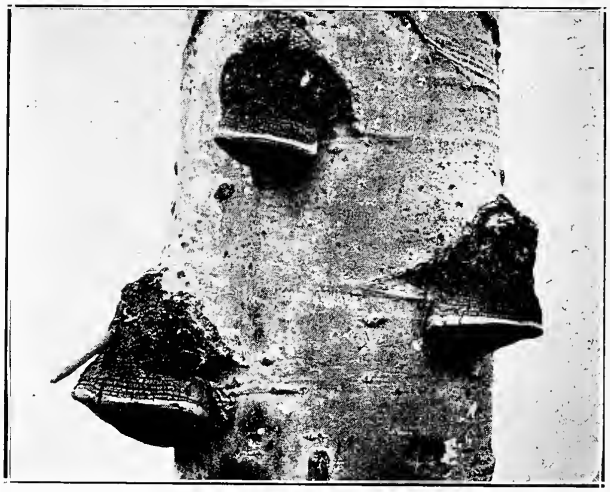

Fig 40. Fomes igniarius on a living aspen. (From Bul. 149, Bureau of Plant Industry, U. S. Dept. of Agricul.)

forms into a white pulpy mass bounded by one or more black layers. During this period of decay the disease cannot be detected from the outside but after the fungus has progressed two or three feet from the point of entrance it comes to the

surface and produces its sporophores or fruiting bodies. (Fig. 40.) These fruiting bodies usually occur at the original wound and are rather conspicuous but variable in shape, size and color. They may be described as hoof-shaped, almost as thick as broad, and sometimes measuring as much as twelve inches in diameter. The upper surface is smooth when young, becoming concentrically marked as it grows older. The outer part is hard, brown, gradually becoming black and cracked with age. The pores within which the spores are produced are formed in layers on the underside. The under surface is gray or red-brown in color, varying with the season. The disease works rather slowly, gradually weakening the tree until it is broken by storms. It is one of the most widely distributed of tree diseases and causes enormous losses which, from their wide geographical distribution and wide range of host plants, are extremely difficult to estimate. See also Polyporus sp., p. 111.

Fruiting bodies.

Treatment.

The most satisfactory treatment for shade and ornamental trees is preventive. When trees become infected the diseased parts should be removed and the wounds properly cared for as recommended on page 44.

Red Heart Rot.

This rot is caused by the parasitic fungus (*Polyporus sulphureus* (Bull.) Fr.). It attacks the oaks, chestnut, maples, walnuts, locusts, alder, ash, poplar, willows, apple, etc., and is widely distributed throughout North America and Europe. It gains entrance through wounds and causes the heart wood to rot and become reddish brown or black, the color varying somewhat with the host plant. After a period of growth within the wood, it comes to the surface producing a number of large

Trees attacked.

shelving sporophores or fruiting bodies (Fig. 41) frequently overlapping. When young the upper surfaces are a bright orange-red with a brighter red rim, very moist, and turn

Fig. 41. Polyporus sulfureus on red oak. (Photo by Dr. W. A. Murrill, N. Y. Botanic Garden.)

brown when bruised. When mature they are hard, dry, brittle and sulphur colored. They are usually destroyed very early by insects. The *treatment* is the same as for the white heart rot.

Fruiting bodies.

P. robiniæ * Murrill attacks the black locust through wounds and completely destroys the heart wood of living trees. The rot begins at the center of the heart and spreads

P. robiniæ Murrill=*P. rimosus* Berkeley.

radially, causing the wood to become soft and yellowish or brownish in color. The sporophores are large and shelving and usually almost twice as wide laterally as from front to back. The proper care of wounds will help to control the disease but it is frequently distributed by the locust borer. (See page 83.) The diseased parts should be removed and destroyed and the wounds treated.

Locust heart rot.

P. juniperinus Schrenk attacks old red cedar trees causing a white heart rot. The fungus probably gains extrance to the tree through dead branches which are most common in old trees. The wood gradually loses its color, becomes whitish and eventually undergoes disintegration leaving holes through the center of branches and trunk. Fruiting bodies are seldom formed. The removal of dead branches and diseased parts will reduce the possibility of infection. *P. carneus* Nees. also causes a white heart rot of both the red cedar and arborvitæ. It has been reported in this State as occurring on dead logs but no doubt is also parasitic. The disease is characterized by the formation of pockets or holes containing more or less brown charcoal-like rotten wood. In advanced stages these holes frequently unite. It should be treated the same as the preceding.

Heart rots of red cedar and arborvitæ.

P. obtusus Berk. causes a soft heart rot of certain species of the oak but is not of such great importance here as farther west. It is readily distributed by the oak borer (*Prionoxystus robiniæ* Peck). It spreads rapidly up and down the trunk and branches causing the heart wood to become soft, white and brittle and very easily broken in slight storms. The sporophores are hoof-shaped, almost white when young, but changing with age to a light brown.

Oak heart rot.

P. fraxinophilus Pk. is the cause of an important disease of the white ash in the Middle West. It occurs as far east as Albany, New York, but has not been reported from New Jersey.

Ash rot.

P. squamosus (Huds) Fr. is not common and is known

White rot.

only in the northern part of the United States. It gains entrance to living trees through wounds, causing a white heart rot. It has been reported on maples, oaks, elm, basswood, willow and ash.

Polystictus vesicolor (L.) Fr. (see below) is the cause of a soft heart rot of the catalpa. The disease starts in the center of the trunk or branch, causing the wood to turn pale and finally a straw yellow color. The diseased wood becomes soft and pithy and easily broken. The disease can usually be recognized by the holes which are formed where diseased branches have been broken off. Trees in the open are not so likely to be attacked as those grown in crowded conditions which result in the natural dying of the lower branches.

Catalpa heart rot.

Treatment.

Careful pruning and treatment of wounds will prove ample protection for shade and ornamental trees.

SAP ROTS.

The sap rots are the cause of considerable losses, and although it is impossible to draw a sharp line of distinction between those which are parasitic and those which are saprophytic, the majority of the sap rot fungi must be considered primarily saprophytes. Among the most important are the following:

The sap rot caused by the fungus (*Polystictus versicolor* (L.) Fr.) is a true saprophyte, except on the Catalpa (see above), and attacks cut and fallen timber of many kinds. Although more of a saprophyte than a parasite, the wide distribution and great abundance of this fungus demands that it should receive some attention in this publication. It is especially destructive on railroad ties, posts and poles. It grows in the sap wood, causing a decay and eventually forming its charac-

Destroys posts, poles &c.

teristic thin, tough, leathery, shelving sporophores. (Fig. 42.) They are variable in size, frequently very numerous and overlapping. The upper surface is marked with con-

Fig. 42. Polystictus versicolor on dead bark. (From Report of Penn. Forestry, 1902, Plate XXII.)

centric zones of various colors while the under surface is usually white. The pores of the under surface, within which the spores are borne, are very small and regular.

Another *sap rot* is caused by *Polystictus pergamenus* Fr. It is usually found on dead trees and is quite common on trees that have been injured by fire. It also occurs on living

oaks, red gum, maples, birch, chestnut, hickory, tulip, poplar, black cherry, beech, willows and others, especially those that have been injured, and is widely distributed throughout North America. However, it has been questioned whether this fungus ever occurs on the living parts of trees. The general appearance of the decay is very similar to that caused by *P. versicolor*. (Fig. 42.) The fruiting bodies are leathery, generally white when young but growing gray with age, the upper surface slightly hairy and the lower surface purplish; the pores are small and tend to produce a ragged surface with age.

Attacks injured trees mostly.

Treatment.

Protection from injury and the proper care of wounds will practically prevent the occurrence of this disease.

P. betulinus (Bull) Fr. is the cause of a sap rot on several species of birch and other trees, but whether parasitic or saprophytic is a disputed point. The same is true of *P. fomentarius* (L.) Fr.

Fomes applanatus (Pers.) Wallr., one of the most conspicuous of our shelving fungi is said to cause a sap rot disease on cottonwoods. However, on most trees it must be considered purely saprophytic.

There are a large number of other sap rots due to a number of species of fungi occurring on many species of trees. Most of them are saprophytic, but some of them are or may become parasitic, especially on trees which are weakened from other causes.

Keep trees healthy.

3. DISEASES OF THE ROOTS.

The diseases of roots are very imperfectly understood. They may be due to unfavorable soil conditions, or to fungi, or to both. Probably the most important of these diseases is the rot due to the fungus *Armillaria mellea* (Vahl.) Que-

let, which is widely distributed throughout North America. The fungus usually gains entrance through wounds, but some authorities claim that it will attack uninjured roots. It causes a decay of the roots, thus cutting off the supply of water and food from the soil and eventually causing the death of the tree. In the roots and surrounding soil will be found the so-called "shoe strings"—hard black strands of the fungus which branch and interlace, draw nourishment from the decaying

Common root rot.

Fig. 43. Armillaria mellea. Parasitic on the roots of many trees. (Courtesy of New York Botanic Garden.)

wood, and finally give rise to the fruiting bodies. The fruiting bodies, a form of mushroom (Fig. 43) appear to grow from the soil, are honey colored, the upper surface viscid and specked with white; the gills of the lower surface white and giving off great quantities of spores; the stems are swollen at the base and have a distinct ring below the umbrella shaped top.

Treatment.

Newly cleared land in which this disease is prevalent should not be set to trees of any kind. When the disease

becomes abundant there is no successful method of control. Diseased trees should be burned, but it is not safe to plant young trees in the same soil.

GAS.

Gas injury. Illuminating gas escaping from defective pipes impregnates the soil, poisons the roots and causes the death of trees. The remedy for this is evident, but in replanting it is frequently necessary to remove the soil from a considerable area and refill with a fresh supply from outside sources. (See page 28.)

4. DISEASES DUE TO ENVIRONMENT.

Plants respond readily to their surroundings, and (in a state of nature, undisturbed by man) the best growths will always be found where the surroundings are most favorable. The most important natural factors which influence the growth of plants are *soil*, *water* and *temperature*. The *soil* may be unfavorable to plant growth owing to the lack, or improper proportions, of food substances; or it may be too shallow or may not hold the proper amount of water. The *water* content of the soil is an important factor, varying with the requirements of the various species of plants. The amount of water that may be unfavorable for a tree will frequently be favorable for the organisms of disease. *Temperature* is also an important factor, both as causing direct injuries which may retard the growth of trees or cause their death, and by making it possible for fungi and other destructive organisms to gain entrance.

Smoke, gases, etc., are also the causes of many injuries and heavy losses. When trees stand close together, the effects of smoke and free gases are first noticed in the tops, but in single trees the injuries may be distributed throughout the crown. As in cases of poisoning by illuminating gas (page 29), the first symptoms are discoloration of the young

leaves followed by slow dying, reduction in the rate of growth of the twigs and, in fact, of the tree generally. Eventually the twigs die and finally the branches and trunks. The different kinds of trees show varying degrees of resistance and, therefore, trees in the vicinity of furnaces, smelters, mills, etc., will not show an equal degree of injury from the central point; some species of trees at considerable distances from the course of smoke and gas may be killed while other species very near may continue to live for many years. "The order of susceptibility, beginning with the trees most easily killed, is as follows: *

"White pine (*Pinus strobus* L.), Hemlock (*Tsuga* sp.), Scrub pine (*Pinus virginiana* Mill.), Pitch pine (*Pinus rigida* Mill.), Chestnut oak (*Quercus prinus* L.), Hickory (*Hicoria* sp.), Black-jack (*Quercus marilandica* Muench.), White oak (*Quercus alba* L.), Post oak (*Quercus minor* (Marsh.) Sargent), Chestnut (*Castanea dentata* (Marsh.) Borkh.), Spanish oak (*Quercus digitata* (Marsh.) Sudworth), Scarlet oak (*Quercus coccinea* Muench.), Tulip poplar (*Liriodendron tulipifera* L.), Maple (*Acer* sp.), Black gum (*Nyssa sylvatica* Marsh.)."

Treatment.

The injuries are greatest to leeward of the prevailing winds. They can be overcome in a great measure by the construction of tall smokestacks which will carry the injurious gases into the higher strata of air. Devices for condensing the gases, such as passing through water, have been used with some degree of success. There is no satisfactory treatment so long as trees are exposed to the abnormal environments. The causes must be removed.

Dust from cement and other establishments has also proved to be the cause of some injuries. When cement dust settles

*Taken from Bulletin No. 149, Bureau of Plant Industry, U. S. Department of Agriculture. Diseases of Deciduous Forest Trees. Herman Von Shrenk and Perley Spaulding.

on the foliage, and is wet by the rains it "sets" and shuts out the light to some extent and reduces the working efficiency of the plant.

5. OTHER DISEASES.

Seed bed disease.

"Damping off" is one of the most destructive diseases of very young plants, especially coniferous trees. It is due to fungi which are semi-saprophytic in habit, living in wet, decaying organic matter, especially in manure. These organisms become especially active under the warm, moist conditions which are favorable for the germination of the seeds and for the growth of the young plants. The fungi attack these seedlings at the surface of the ground causing them to wilt, fall over and die. The fungi continue to live on the dead plants and spread to the living seedlings. The disease is especially prevalent in seed beds and in nature where the plants are growing in crowded conditions. These diseases are responsible in a great measure for the difficulties in growing coniferous seedlings and other nursery stock in America.

Treatment.

The "damping off" fungi can be controlled to some extent in various ways. One of the most common practices is that of burning a large quantity of vegetable material on the surface of the bed before planting. Formalin disfection of the soil is also used extensively. By this method the beds are thoroughly prepared and then drenched with a formalin solution (1 part commercial formalin to 150 to 200 parts water) using three or four quarts to each square foot of bed surface. The beds should then be covered with burlap for 24 hours and after that thoroughly aired for about a week. In some cases it may be necessary to make two or three applications, dependent on the character of the soil. This

treatment must be used with care, as it will sometimes reduce the germinating power of the seeds.

Insects are the cause of many diseases, among the most interesting of which are the cecidia or galls. These abnormal growths occur on roots, stems, leaves, flowers and fruits and are due to insect injuries, in most cases the insects making their homes for a considerable part of their lives within the galls. Some of them are very injurious, but most of those occurring on trees are considered of little importance. However, individual plants are frequently so seriously affected as to mar their beauty and no doubt reduce their vitality. The great regularity of shape, color and markings of these galls will always make them objects of great interest to both scientist and layman, and future studies will probably prove them to be the cause of greater injuries than we now attribute to them. Fortunately, owing to the migratory character of the insects, most species of insect galls do not occur two or more years in succession on the same trees. Some few species can be sprayed to advantage with insecticides, but in most cases where the pests become troublesome it will be found necessary to prune and destroy the diseased parts before the insects emerge.

Galls not often harmful.

Abnormal structures are also formed as a result of fungus, bacterial and mechanical injuries.

Animal injuries of various kinds are frequently the openings by which fungi and other organisms of disease gain entrance to the host plants. Insects, birds, squirrels and other animals are also the distributers of many diseases by making wounds and carrying the organisms from place to place. Storms also aid in the work of destruction by breaking branches and thus causing wounds which immediately become sources of infection.

Injuries promote disease.

METHODS OF CONTROL.

It will be readily seen that the treatment of trees must be primarily protective, rather than curative. It is impossible to use orchard methods in the forests and frequently impractical to use such methods on shade and ornamental trees. Good forestry practice in the forest and proper care of shade and ornamental trees will greatly reduce the ravages of many of these diseases.

Prevention better than cure.

The heart and sap rots usually (probably always) originate with wounds through which the organisms gain entrance. Of course not all wounds give rise to diseases any more than all wounds of human beings and lower animals give rise to blood poisoning, but all wounds must be looked upon as points where infections are likely to occur and therefore as sources of danger. Frequent inspection of shade and ornamental trees, the cutting out of broken branches, proper pruning, and the care of all wounds are important factors in preserving the beauty and contributing to longevity. (See page 26.) Decaying wood forms a most excellent garden for many fungi which are both saprophytic and parasitic in habit. It should always be removed and burned.

Wounds induce decay.

Spraying may be practiced to some extent for foliage diseases on shade and ornamental trees, especially small ones. Among the most important of the spraying mixtures is lime-sulphur which is used extensively for scale insects. It is also a fungicide and will reduce the organisms that winter on the stems and trunk.

Spraying mixtures.

Bordeaux mixture is the old and reliable fungicide and can be used on most trees for foliage diseases. However, it is unsafe for some trees and has the disadvantage of discoloring the parts to which it is applied. Where the discolorations are undesirable, the ammoniacal-copper-carbonate solution can frequently be used to

advantage. Potassium sulphide solution is a very useful remedy where it is desirable to protect ornamentals against powdery mildews and other superficial fungi.

FUNGICIDES.

Bordeaux Mixture.

Copper sulphate	2 to 5 pounds
Quick lime	3 to 6 pounds
Water	50 gallons

This is one of the oldest and most reliable fungicides known. The lime is to prevent certain injuries which might otherwise arise from the use of copper sulphate and the amount should always be slightly in excess of the amount of the copper sulphate. The copper sulphate is dissolved in a small quantity of water by suspending the crystals in a bag at the surface. The lime is slacked in a small quantity of water. Each mixture is then diluted to 25 gallons and the two are poured together. The copper sulphate may be dissolved, and the lime slacked, and the two kept as stock for dilution and use as needed but the mixture will not keep after being poured together. The strength of Bordeaux mixture varies with the character of the foliage of the plants to be treated, since the foliage of many tender plants will be injured by it.

Copper Sulphate.

One pound of copper sulphate dissolved in 25 gallons of water makes an excellent winter spray but cannot be used on plants when in foliage.

Lime-Sulphur.

This mixture has come into general use as a winter spray and has largely superseded copper sulphate since it serves as both a fungicide and an insecticide. The commercial prod-

uct used in the proportion of 1 gallon to 10 gallons of water is very satisfactory, but cannot be used on foliage. For trees in leaf a mixture of 1 gallon in 30 gallons of water is as strong as is safe. This mixture can be made at home according to the formula given in our State and government publications, but most people find it more satisfactory to use the commercial product.

Ammonia-copper-carbonate mixture.

Copper carbonate	6 oz.
Ammonia (26° Beaumé)	3 pts.
Water	50 gal.

Dissolve the copper carbonate in the ammonia and dilute with water. This mixture has the advantage of not discoloring the foliage. It is rather unreliable and should be used with care and always tested on a single plant, or small part of a plant, before general application.

Potassium sulphide.

Potassium sulphide (liver of sulfur),	¾ to 1½ lbs.
Water	50 gal.

This treatment is very successful on the surface-growing fungi, such as the mildews, but of no value on the more vigorous parasites.

Sprayers.

Spraying pumps and machines are easily obtained of any seed house. For information regarding forms and sizes see page 88.

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